FY 2005

Small Business Innovation Research PROGRAM SOLICITATION

Opening Date: November 5, 2004
Closing Date: January 28, 2005

NIST-05-SBIR

U.S. DEPARTMENT OF COMMERCE
National Institute of Standards and Technology

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US DEPARTMENT OF COMMERCE
NATIONAL INSTITUTE OF STANDARDS AND TECHNOLOGY
SOLICITATION FOR SMALL BUSINESS INNOVATION RESEARCH (SBIR) PROGRAM

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US DEPARTMENT OF COMMERCE
NATIONAL INSTITUTE OF STANDARDS AND TECHNOLOGY

SOLICITATION FOR SMALL BUSINESS INNOVATION RESEARCH (SBIR) PROGRAM

1.0 PROGRAM DESCRIPTION

1.01 Introduction

The Department of Commerce (DOC) National Institute of Standards and Technology (NIST) invites small businesses to submit research proposals under this solicitation. Firms with strong research capabilities in any of the areas listed in Section 9 of this solicitation are encouraged to participate. Unsolicited proposals are not accepted under the SBIR program.

Objectives of this program include stimulating technological innovation in the private sector and strengthening the role of small business in meeting Federal research and development (R&D) needs. This program also seeks to increase the commercial application of innovations derived from Federal research and improve the return on investment from federally funded research for the economic benefit of the Nation.

1.02 Three-Phase Program

The "Small Business Research and Development Enhancement Act of 1992", as amended, requires the Department of Commerce to establish a three-phase SBIR program by reserving a percentage of its extramural R&D budget to be awarded to small business concerns for innovation research.

This document solicits Phase 1 proposals only.

NIST has the unilateral right to select SBIR research topics and awardees in both Phase 1 and Phase 2. As funding is limited, NIST reserves the right to select and fund only those proposals deemed to be superior in overall technical quality and highly relevant to the NIST mission. As a result, NIST may fund more than one proposal in a specific topic area if the technical quality of the proposal(s) is deemed superior or it may not fund any proposals in a given topic area.

1.02.01 Phase 1 - Feasibility Research

The purpose of Phase 1 is to determine the technical feasibility of the proposed research and the quality of performance of the small business concern receiving an award. Therefore, the proposal should concentrate on research that will significantly contribute to proving the feasibility of the proposed research, a prerequisite to further support in Phase 2.

1.02.02 Phase 2 - Research and Development

Only firms that receive Phase 1 awards will be given the opportunity of submitting a Phase 2 proposal following completion of Phase 1. Instructions for Phase 2 proposal preparation and submission will be provided to Phase 1 awardees typically during the fourth month of the Phase 1 period of performance.

Phase 2 is the R&D or prototype development phase. It will require a comprehensive proposal outlining the research in detail. Further information regarding Phase 2 proposal requirements will be provided to all firms receiving Phase 1 awards.

1.02.03 Phase 3 - Commercialization

In Phase 3, it is intended that non-SBIR capital be used by the small business to pursue commercial applications of Phase 2.

1.03 Manufacturing-related Priority

Executive Order (EO) 13329 “Encouraging Innovation in Manufacturing” requires SBIR agencies, to the extent permitted by law and in a manner consistent with the mission of that department or agency, to give high priority within the SBIR programs to manufacturing-related research and development (R&D). “Manufacturing-related” is defined as “relating to manufacturing processes, equipment and systems; or manufacturing workforce skills and protection.” More information on the national manufacturing initiative may be found through links located on the NIST SBIR website www.nist.gov/sbir

The NIST SBIR Program solicits manufacturing-related projects through many of the subtopics described in this Solicitation. Further NIST encourages innovation in manufacturing by giving high priority, where feasible, to projects that can help the manufacturing sector through technological innovation in a manner consistent with NIST’s mission.

1.04 Eligibility

Each organization submitting a proposal for both Phase 1 and Phase 2 must qualify as a small business concern (Section 2.10) for research or R&D purposes (Section 2.7) at the time of award. In addition, the primary employment of the principal investigator must be with the small business at the time of the award and during the conduct of the proposed research. More than one-half of the principal investigator's time must be spent with the small business for the period covered by the award. Primary employment with a small business precludes full-time employment with another organization.

Also, for both Phase 1 and Phase 2, the work must be performed in the United States. "United States" means the fifty states, the territories and possessions of the United States, the Commonwealth of Puerto Rico, the Commonwealth of the Northern Mariana Islands, the Trust Territory of the Pacific Islands, and the District of Columbia. However, based on a rare and unique circumstance, for example, a supply or material or other item or project requirement that is not available in the United States, agencies may allow that particular portion of the R/R&D work to be performed or obtained in a country outside of the United States. Approval by the funding agreement officer after consultation with the agency SBIR Program Manager/Coordinator for each such specific condition must be in writing.

Joint ventures and limited partnerships are eligible, provided the entity created qualifies as a small business as defined in this solicitation. Consultative arrangements between firms and universities or other non-profit organizations are encouraged, with the small business serving as the awardee.

For Phase 1, a minimum of two-thirds of the research and/or analytical effort must be performed by the awardee. For Phase 2 - a minimum of one-half of the research and/or analytical effort must be performed by the awardee.

Unsolicited proposals or proposals not responding to stated topics or subtopics are not eligible for SBIR awards.

Phase 2 proposals may be submitted only by Phase 1 awardees.

1.05 Contact with NIST

In the interest of competitive fairness, all oral or written communication with NIST concerning a specific technical topic or subtopic during the open solicitation period is strictly prohibited - with the exception of the public discussion group located at www.nist.gov/sbir. Discussion group questions will be routed to the appropriate person for a response. All questions and responses will be publicly, though anonymously, posted on the discussion group web site.

Potential awardees may not participate in the selection of any topic or subtopic nor in the review of proposals. All offerors, including Guest Researchers, contractors, Cooperative research and Development Agreement (CRADA) partners and others working with NIST may only submit a proposal if they:

> Had no role in suggesting, developing, or reviewing the subtopic; and
>
> Have not been the recipient of any information on the subtopic not available in the solicitation or other public means; and
>
> Have not received any assistance from DOC in preparing the proposal (including any 'informal' reviews) prior to submission.
>
> An Agency may not enter into, or continue an existing CRADA with an awardee on the subtopic of the award.

Requests for general information on the NIST SBIR program may be addressed to:

> SBIR Program
> 100 Bureau Drive, Stop 2200
> Gaithersburg, MD 20899-2200
> Telephone: (301) 975-3085, Fax: (301) 548-0624
> email: sbir@nist.gov

For information on contractual issues contact:

> Lisa Wells
> Acquisition Management Division
> Telephone: (301) 975-8171. Fax: (301) 975-8884
> email: lisa.wells@nist.gov

2.0 DEFINITIONS

2.01 Commercialization

This is locating or developing markets and producing and delivering products for sale (whether by the originating party or by others). As used here, commercialization includes both Government and private sector markets.

2.02 Essentially Equivalent Work

This occurs when (1) substantially the same research is proposed for funding in more than one contract proposal or grant application submitted to the same Federal agency; (2) substantially the same research is submitted to two or more different Federal agencies for review and funding consideration; or (3) a specific research objective and the research design for accomplishing an objective are the same or closely related in two or more proposals or awards, regardless of the funding source.

2.03 Feasibility

The extent to which a project may be done practically and successfully.

2.04 Funding Agreement.

Any contract, grant, or cooperative agreement entered into between any Federal agency and any SBC for the performance of experimental, developmental, or research work, including products or services, funded in whole or in part by the Federal Government.

NIST will utilize contracts as the funding agreement for its SBIR awards.

2.05 Joint Venture

An association of persons or concerns with interests in any degree or proportion by way of contract, express or implied, consorting to engage in and carry out a single specific business venture for joint profit, for which purpose they combine their efforts, property, money, skill, or knowledge, but not on a continuing or permanent basis for conducting business generally. A joint venture is viewed as a business entity in determining power to control its management and is eligible under the SBIR and STTR Programs provided that the entity created qualifies as a "small business concern" as defined in herein.

2.06 Primary Employment

Primary employment means that more than one half of the principal investigator's time is spent in the employ of the small business concern. This requirement extends also to “leased” employees serving as the principal investigator. Primary employment with a small business concern precludes full time employment at another organization.

2.07 Research or Research and Development

Any activity that is (a) a systematic, intensive study directed toward greater knowledge or understanding of the subject studied; (b) a systematic study directed specifically toward applying new knowledge to meet a recognized need; or (c) a systematic application of knowledge toward the production of useful materials, devices, services, or methods, and includes design, development, and improvement of prototypes and new processes to meet specific requirements.

In general, the NIST SBIR program will fund Phase 1 and 2 proposals with objectives that can be defined by (b) and (c) above.

2.08 SBIR Technical Data

All data generated during the performance of an SBIR award.

2.09 SBIR Technical Data Rights

The rights an small business concern (SBC) obtains in data generated during the performance of any SBIR Phase 1, Phase 2, or Phase 3 award that an awardee delivers to the Government during or upon completion of a Federally-funded project, and to which the Government receives a license.

2.10 Small Business Concern (SBC)

A small business concern (SBC) is one that, at the time of award for Phase 1 and Phase 2:

(a) is organized for profit, with a place of business located in the United States, which operates primarily within the United States or which makes a significant contribution to the United States economy through payment of taxes or use of American products, materials or labor;

(b) is in the legal form of an individual proprietorship, partnership, limited liability company, corporation, joint venture, association, trust or cooperative, except that where the form is a joint venture, there can be no more than 49 percent participation by foreign business entities in the joint venture;

(c) is at least 51 percent owned and controlled by one or more individuals* who are citizens of, or permanent resident aliens in, the United States, except in the case of a joint venture, where each entity to the venture must be 51 percent owned and controlled by one or more individuals who are citizens of, or permanent resident aliens in, the United States; and

(d) has, including its affiliates, not more than 500 employees.

2.11 Socially and Economically Disadvantaged Small Business Concern

Is one that is:

(a) at least 51 percent owned by (1) an American Indian tribe or a native Hawaiian organization, or (2) one or more socially and economically disadvantaged individuals, and

(b) controlled by one or more such individuals in its management and daily business operations.

A socially and economically disadvantaged individual is defined as a member of any of the following groups: Black Americans, Hispanic Americans, Native Americans, Asian-Pacific Americans, Subcontinent Asian Americans, or any other individual found to be socially and economically disadvantaged by the Small Business Administration (SBA) pursuant to Section 8(a) of the Small Business Act, 15 US Code (U.S.C.) 637(a). See 13 CFR Part 124 -- 8(A) Business Development/Small Disadvantaged Business Status Determinations, §§124.103 (Who is socially disadvantaged?) and 124.104 (Who is economically disadvantaged?).

2.12 Subcontract

This is any agreement, other than one involving an employer-employee relationship, entered into under a Federal Government funding agreement, calling for supplies or services required solely for the performance of the original funding agreement.

2.13 Women-Owned Small Business

A small business that is at least 51 percent owned by a woman or women who also control (meaning to exercise the power to make policy decisions) and operate (meaning being actively involved in the day-to-day management) the small business concern.

3.0 PROPOSAL PREPARATION GUIDELINES

3.01 Proposal Requirements

NIST reserves the right to not submit to technical review any proposal which it finds to have insufficient scientific and technical information, or one which fails to comply with the administrative procedures as outlined on the Checklist of Requirements in Section 8.04. Proposals that do not successfully pass the screening criteria given in Section 4.02 will be returned to the offeror without consideration.

The objective is to provide sufficient information to demonstrate that the proposed work represents a sound approach to the investigation of an important scientific or engineering innovation worthy of support. The proposal must meet all the requirements of the subtopic in Section 9 to which it applies.

A proposal must be self-contained and written with all the care and thoroughness of a scientific paper submitted for publication. It should indicate a thorough knowledge of the current status of research in the subtopic area addressed by the proposal. Each proposal should be checked carefully by the offeror to ensure inclusion of all essential material needed for a complete evaluation. The proposal will be peer reviewed as a scientific paper. All units of measurement should be in the metric system.

The proposal must not only be responsive to the specific NIST program interests described in Section 9 of the solicitation, but also serve as the basis for technological innovation leading to new commercial products, processes, or services that benefit the public. An organization may submit different proposals on different subtopics or different proposals on the same subtopic under this solicitation. When the proposed innovation applies to more than one subtopic, the offeror must choose that subtopic which is most relevant to the offeror's technical concept.

Proposals principally for the commercialization of proven concepts or for market research must not be submitted for Phase 1 funding, since such efforts are considered the responsibility of the private sector.

The proposal should be direct, concise, and informative. Promotional and other material not related to the project shall be omitted. The complete proposal application must contain four copies of the following:

(a) Cover Sheet
(b) Project Summary
(c) Technical Content
(d) Proposed Budget

All signatures in each of the four copies MUST be ORIGINAL, i.e. no photocopies of signatures will be accepted.

3.02 Phase 1 Proposal Limitations

Page length must be no more than 25 pages. Each page is to be consecutively numbered, including the cover sheet (2 pages count as one), project summary, main text, references, resumes, any other enclosures or attachments, and the proposal summary budget. The only exception to the page count limitation are those pages necessary to comply with the itemization of prior SBIR phase 2 awards, per Section 3.03.03.02.

Paper size used for the submission must be 21.6 cm X 27.9 cm (8 ½" X 11"). Print size used for the submission must be easy to read with a fixed pitch font of 12 or fewer characters per inch or proportionally spaced font of point size 10 or larger with no more than 6 lines per inch.

Supplementary material, revisions, substitutions, audio or video tapes, or computer floppy disks will not be accepted.

The original and all copies of each proposal should be mailed in one package.

Proposals not meeting these requirements will be returned without review.

3.03 Instructions for Phase 1 Proposal Submission Forms and Technical Content

Instructions for completing each of the three required forms is contained in this section as well as the format required for the Technical Content section. A complete proposal application must include four copies of each of the following: Cover Sheet, Project Summary, Technical Content, and Proposed Budget. The forms: Cover Sheet, Project Summary, and Proposed Budget are downloadable forms that may be found on fedbizops or the NIST SBIR web site. Any applications received that are missing any of these required items will be returned without review.

3.03.01 Cover Sheet

Complete all items in Cover Sheet and use as page 1 of the proposal. NO OTHER COVER WILL BE ACCEPTED. Photocopies are permitted, though signatures must be original.

No award shall be made under this solicitation to a small business concern without registration in CCR or a DUNS number.

Before NIST can award a contract to a successful offeror under this solicitation, the offeror must be registered in the DoD Central Contractor Registration (CCR) database. The CCR allows Federal Government contractors or firms interested in conducting business with the federal government to provide basic information on business capabilities and financial information. To register, visit www.ccr.gov or call 1-888-227-2423.

The DUNS number is a nine-digit number assigned by Dun and Bradstreet Information Services. If the offeror does not have a DUNS number, it should contact Dun and Bradstreet directly to obtain one. A DUNS number will be provided immediately by telephone at no charge to the offeror. For information on obtaining a DUNS number, the offeror, if located within the United States, should call Dun and Bradstreet at 1-800-333-0505. The offeror should be prepared to provide information such as: Company name, address, and telephone number, Line of business, Chief executive officer/key manager, Date the company was started, Number of people employed by the company, Company affiliation.

Offerors located outside the United States may obtain the location and phone number of the local Dun and Bradstreet Information Services office from the Internet home page at http://sbs.dnb.com. If an offeror is unable to locate a local service center, it may send an e-mail to Dun and Bradstreet at globalinfo@mail.dnb.com.

3.03.02 Project Summary

Complete all sections "Project Summary" as page 2 of your proposal. The technical abstract should include a brief description of the problem or opportunity, the innovation, project objectives, and technical approach. Keywords should be chosen to describe the proposed work both generally and specifically. In summarizing anticipated results, include technical implications of the approach and the potential commercial applications of the research. The Project Summary of proposals that receive an award will be published by NIST and, therefore, must not contain proprietary information.

3.03.03 Technical Content

Beginning on page 3 of the proposal, include the following items with headings as shown:

(a) Identification and Significance of the Problem or Opportunity. Make a clear statement of the specific research problem or opportunity addressed, its innovativeness, commercial potential, and why it is important. Show how it applies to a specific subtopic in Section 9.

(b) Phase 1 Technical Objectives. State the specific objectives of the Phase 1 effort, including the technical questions it will try to answer, to determine the feasibility of the proposed approach.

(c) Phase 1 Work Plan. Include a detailed description of the Phase 1 R&D plan. The plan should indicate what will be done, where it will be done, and how the R&D will be carried out. The methods planned to achieve each objective or task should be discussed in detail. This section should be at least one-third of the proposal. NIST technical support or assistance may be available to awardees in the conduct of the research only if specifically provided for in the subtopic description. NIST may not enter into, nor continue, a CRADA with an awardee on the subtopic of the award.

(d) Related Research or R&D. Describe research or R&D that is directly related to the proposal, including any conducted by the principal investigator or by the offeror's firm. Describe how it relates to the proposed effort, and describe any planned coordination with outside sources. The purpose of this section is to persuade reviewers of the offeror's awareness of recent developments in the specific topic area.

(e) Key Personnel and Bibliography of Related Work. Identify key personnel involved in Phase 1, including their related education, experience, and publications. Where resumes are extensive, summaries that focus on the most relevant experience and publications are suggested. List all other commitments that key personnel have during the proposed period of contract performance.

(f) Relationship with Future R&D. Discuss the significance of the Phase 1 effort in providing a foundation for the Phase 2 R&D effort. Also state the anticipated results of the proposed approach, if Phases 1 and 2 of the project are successful.

(g) Facilities and Equipment. The conduct of advanced research may require the use of sophisticated instrumentation or computer facilities. The offeror should provide a detailed description of the availability and location of the facilities and equipment necessary to carry out Phase 1. NIST facilities and/or equipment may be available for use by awardees only if specifically provided for in the subtopic description.

(h) Consultants and Subcontracts. The purpose of this section is to convince NIST that:

(1) research assistance from outside the firm materially benefits the proposed effort, and
(2) arrangements for such assistance are in place at the time the proposal is submitted.

Outside involvement in the project is encouraged where it strengthens the conduct of the research. Outside involvement is not a requirement of this solicitation. Outside involvement is limited to no more than 1/3 of the research and/or analytical effort, per section 1.03.

1. Consultant - A person outside the firm, named in the proposal as contributing to the research, must provide a signed statement confirming his/her availability, role in the project, and agreed consulting rate for participation in the project. This statement is part of the page count.

2. Subcontract - Similarly, where a subcontract is involved in the research, the subcontracting institution must furnish a letter signed by an appropriate official describing the programmatic arrangements and confirming its agreed participation in the research, with its proposed budget for this participation. This letter is part of the page count.

No individual or entity may serve as a consultant or subcontractor if they:
Had any role in suggesting, developing, or reviewing the subtopic; or
Have been the recipient of any information on the subtopic not available to the public.

(i) Potential Commercial Application and Follow-on Funding Commitment. Describe in detail the commercial potential of the proposed research, how commercialization would be pursued and potential use by the Federal Government.

(j) **Cooperative Research and Development Agreements (CRADA).** State if the offeror is a former or current CRADA partner with NIST, or with any other Federal agency, naming the agency, title of the CRADA, and any relationship with the proposed work. An Agency may not enter into, nor continue, a CRADA with an awardee on the subtopic of the award.

(k) **Guest Researcher.** State if the applicant is a guest researcher at NIST, naming the sponsoring laboratory.

(l) **Cost Sharing.** Cost participation could serve the mutual interest of NIST and certain SBIR contractors by helping to assure the efficient use of available resources. Except where required by other statutes, NIST does not encourage or require cost sharing on Phase 1 projects, nor will cost sharing be a consideration in evaluation of Phase 1 proposals.

3.03.03.01 Similar Proposals or Awards

WARNING - While it is permissible, with proposal notification, to submit identical proposals or proposals containing a significant amount of essentially equivalent work for consideration under numerous Federal program solicitations, it is unlawful to enter into funding agreements requiring essentially equivalent work. If there is any question concerning this, it must be disclosed to the soliciting agency or agencies before award. If an applicant elects to submit identical proposals or proposals containing a significant amount of essentially equivalent work under other Federal program solicitations, a statement must be included in each such proposal indicating:

(i) The name and address of the agencies to which proposals were submitted or from which awards were received.
(ii) Date of proposal submission or date of award.
(iii) Title, number, and date of solicitations under which proposals were submitted or awards received.
(iv) The specific applicable research topics for each proposal submitted or award received.
(v) Titles of research projects.
(vi) Name and title of principal investigator or project manager for each proposal submitted or award received.

If no equivalent proposal is under consideration or equivalent award received, a statement to that effect must be included in this section of the technical content area of the proposal and certified within the Cover Sheet.

3.03.03.02 Prior SBIR Phase 2 Awards

If the small business concern has received more than 15 Phase 2 awards in the prior 5 fiscal years, it must submit in its Phase 1 proposal: name of the awarding agency; date of award; funding agreement number; amount of award; topic or subtopic title; follow-on agreement amount; source and date of commitment; and current commercialization status for each Phase 2 award. **This required information shall not be part of the 25 page count limitation.**

NOTE: The Small Business Administration is mandated to establish an SBIR awardee database containing demographic, technical, outcome and output information on all SBIR awards. The database is still being developed as of the date of release of this solicitation. When it becomes available, all NIST SBIR awardees will be required to supply the required data in a timely fashion.

3.03.04 Proposed Budget

NIST will not issue SBIR awards that include provisions for subcontracting any portion of the contract back to the federal government.

For Phase 1, a minimum of two-thirds of the research and/or analytical effort must be performed by the proposing small business concern. For Phase 2 a minimum of one-half of the research and/or analytical effort must be performed by the proposing small business concern.

If the independent contractors are working directly for the small business and are listed in the cost proposal as labor line items and not as a subcontractor, they should be considered as part of the SBC's 2/3 efforts. Similarly, fabrications delivered by a third party per the SBC's design specifications, should be considered as part of the SBC's 2/3 effort.

Complete the Proposed Budget for the Phase 1 effort, and include it as the last page of the proposal. Some items of this form may not apply. Enough information should be provided to allow NIST to understand how the offeror plans to use the requested funds if the award is made. A complete cost breakdown should be provided giving labor rates, proposed number of hours, overhead, G&A, and profit. A reasonable profit will be allowed.

The offeror is to submit a cost estimate with detailed information for each Line Item, consistent with the offeror's cost accounting system. This does not eliminate the need to fully document and justify the amounts requested in each category. Such documentation should be contained, as appropriate, within the proposal technical content.

Lines A and B, Labor. List the key personnel and consultants by name and function or role in the project. Other direct personnel need not be named, but their role, such as “technician,” and total hours should be entered. Personnel whose costs are indirect (e.g. administrative personnel) should be included in Line D. Fringe benefits can be listed for each employee in the space provided, or they may be included within the indirect costs in Line G. The PI must be employed by the small business concern at the time of contract award and during the period of performance of the research effort. Additionally, more than half of the PI's time must be spent with the small business firm during the contract performance.

Line C, Equipment. List items costing over $5,000 and exceeding 1 year of useful life. Lesser items may be shown in Line D. Indicate if equipment is to be purchased or leased. Where equipment is to be purchased or leased, list each individual item with the corresponding cost. The inclusion of equipment will be carefully reviewed relative to need and appropriateness for the research proposed.

Line D, Other Direct Costs. The materials and supplies required for the project must be identified. There is also a need to specify type, quantity, unit cost, and total estimated cost of these materials and supplies. List all other direct costs that are not described above (i.e. consultants, subcontractor, travel, and equipment purchases). Each of the above needs a detailed explanation and elaboration of its relation to the project. Use a “Budget Explanation Page” for entries requiring an explanation.

Line E, Travel. Itemize by destination, purpose, period and cost for both staff and consultants. Budgets including travel funds must be justified and related to the needs of the project. Inclusion of travel expenses will be carefully reviewed relative to need and appropriateness for the research proposed. Foreign travel is not an appropriate expense.

Line F, Total Direct Costs. Enter the sum of Lines A through E.

Line G, Indirect Costs. Cite your established Overhead (OH) and General and Administrative (G&A) rate, if any. Otherwise include all indirect costs (e.g. facilities, shared equipment, utilities, property taxes, administrative staff) for the period of the project. Indirect costs are costs not directly identified with a single final cost objective.

Line H, Total Costs. Enter the total amount of the proposed project, the sum of Lines F and G.

Line I, Profit. The small business may request a reasonable profit.

Line J, Total Amount of this request. Enter the sum of Lines H and I. This amount must equal the amount entered in the Cover Sheet Form.

Line K, Corporate/Business Authorized Representative. An original signature of someone with the authority to commit the company must be given.

4.0 METHOD OF SELECTION AND EVALUATION CRITERIA

4.01 Introduction

All Phase 1 and 2 proposals will be evaluated and judged on a competitive basis. Proposals will be initially screened to determine responsiveness. Proposals passing this initial screening will be technically evaluated by engineers or scientists to determine the most promising technical and scientific approaches. Each proposal will be judged on its own merit. The Agency is under no obligation to fund any proposal or any specific number of proposals in a given topic. It also may elect to fund several or none of the proposed approaches to the same topic or subtopic

4.02 Phase 1 Screening Criteria

To avoid misunderstanding, small businesses are cautioned that Phase 1 proposals not satisfying all the screening criteria below shall be returned to the offeror without peer review and will be eliminated from consideration for funding. Proposals may not be resubmitted (with or without revision) under this solicitation. The screening criteria are:

(a) The proposing firm must qualify as eligible according to the criteria set forth in Section 1.03.

(b) The Phase 1 proposal must meet **all** of the requirements stated in Section 3.

(c) The Phase 1 proposal must be limited to one subtopic and clearly address research for that subtopic.

(d) **Phase 1 proposal budget must not exceed $75,000**, including subcontract, indirect cost, and fee.

(e) **The project duration for the Phase 1 research must not exceed 6 months.**

(f) The proposal must contain information sufficient to be peer reviewed as research.

4.03 Phase 1 Evaluation Criteria

Phase 1 proposals that comply with the screening criteria will be rated by NIST scientists or engineers in accordance with the following criteria:

(a) The scientific and technical merit of the proposed research (25 points)

(b) Innovation, originality, and feasibility of the proposed research (25 points)

(c) Relevance and responsiveness of the proposed research to the subtopic to which it is addressed (25 points)

(d) Quality and/or adequacy of facilities, equipment, personnel described in the proposal (15 points)

(e) Quality of the proposal with respect to potential commercialization and/or Federal Procurements of the products and/or services sought by the subtopic (10 points)

Technical reviewers will base their ratings on information contained in the proposal. It cannot be assumed that reviewers are acquainted with any experiments referred to, key individuals, or the firm.

Final award decisions will be made by NIST based upon ratings assigned by reviewers and consideration of additional factors, including possible duplication of other research, the importance of the proposed research as it relates to NIST needs, and the availability of funding. In the event of a "tie" between proposals, manufacturing-related projects will receive a priority in the award selection process. NIST may elect to fund several or none of the proposals received on a given subtopic. Upon selection of a proposal for a Phase 1 award, NIST reserves the right to negotiate the amount of the award.

4.04 Phase 2 Evaluation Criteria

The Phase 2 proposal will undergo NIST and/or external peer review in accordance with the following criteria:

1. Degree to which Phase I objectives were met (25 points)
2. The scientific and technical merit of the proposed research, including innovation, originality, and feasibility (25 points)

3. Quality and/or adequacy of facilities, equipment, personnel described in the proposal (25 points)
4. Quality of the offeror and the proposal with respect to potential commercialization and/or Federal Procurements of the products and/or services sought by the subtopic. This involves some or all of the following factors, as appropriate; how well the proposal meets NIST mission/OU program needs; offeror's record of successful commercialization and/or Federal Procurement of research in the past; existence of non-SBIR Phase 2 funding commitments, existence of Phase 3 funding or partnering commitments (25 points)

4.05 Release of Proposal Review Information

After final award decisions have been announced, the technical evaluations of a proposal that passed the screening criteria will be provided to the offeror with written notification of award/non-award. The identity of the reviewers will not be disclosed.

5.0 CONSIDERATIONS

5.01 Awards

NIST awards firm-fixed-price contracts as the type of funding agreement to successful offerors. A firm-fixed-price contract provides for a price that is not subject to any adjustment on the basis of the contractor's cost experience in performing the contract. This contract type places upon the contractor the risk and full responsibility for all costs and resulting profit or loss. It provides maximum incentive for the contractor to control costs and perform effectively and imposes a minimum administrative burden upon both contracting parties. NIST also does not allow any advance payments to be made on its contract awards.

Contingent upon availability of funds, NIST anticipates making about 28 Phase 1 firm-fixed-price awards of no more than $75,000 each. The performance period for Phase 1 shall be no more than 6 months beginning on the contract start date.

Phase 2 awards shall be for no more than $300,000. The period of performance in Phase 2 will depend upon the scope of the research, but should not exceed 24 months. Letters of instruction will be sent to those Phase 1 awardees eligible to submit Phase 2 proposals. The Phase 2 proposals are due shortly after the deadline for Phase 1 final reports - 7 months after commencement of the Phase 1 contract.

It is anticipated that approximately one-fourth of the Phase 1 awardees will receive Phase 2 awards, depending upon the availability of funds. To provide for an in-depth review of the Phase 1 final report and the Phase 2 proposal and commercialization plan, Phase 2 awards will be made approximately 5 months after the completion of Phase 1, contingent upon availability of funds.

This solicitation does not obligate NIST to make any awards under either Phase 1 or Phase 2. Furthermore, NIST is not responsible for any monies expended by the offeror before any award is made resulting from this solicitation.

Upon award of a funding agreement, the awardee will be required to make certain legal commitments through acceptance of numerous clauses in Phase I funding agreements. The outline that follows is illustrative of the types of clauses to which the contractor would be committed. This list is not a complete list of clauses to be included in Phase I funding agreements, and is not the specific wording of such clauses. Copies of complete terms and conditions are available upon request.

These statements are examples only and may vary depending upon the type of funding agreement used.

(1) Standards of Work. Work performed under the funding agreement must conform to high professional standards.
(2) Inspection. Work performed under the funding agreement is subject to Government inspection and evaluation at all times.
(3) Examination of Records. The Comptroller General (or a duly authorized representative) must have the right to examine any pertinent records of the awardee involving transactions related to this funding agreement.
(4) Default. The Government may terminate the funding agreement if the contractor fails to perform the work contracted.
(5) Termination for Convenience. The funding agreement may be terminated at any time by the Government if it deems termination to be in its best interest, in which case the awardee will be compensated for work performed and for reasonable termination costs.
(6) Disputes. Any dispute concerning the funding agreement that cannot be resolved by agreement must be decided by the contracting officer with right of appeal.
(7) Contract Work Hours. The awardee may not require an employee to work more than 8 hours a day or 40 hours a week unless the employee is compensated accordingly (for example, overtime pay).
(8) Equal Opportunity. The awardee will not discriminate against any employee or applicant for employment because of race, color, religion, sex, or national origin.
(9) Affirmative Action for Veterans. The awardee will not discriminate against any employee or application for employment because he or she is a disabled veteran or veteran of the Vietnam era.
(10) Affirmative Action for Handicapped. The awardee will not discriminate against any employee or applicant for employment because he or she is physically or mentally handicapped.
(11) Officials Not To Benefit. No Government official must benefit personally from the SBIR funding agreement.
(12) Covenant Against Contingent Fees. No person or agency has been employed to solicit or secure the funding agreement upon an understanding for compensation except bona fide employees or commercial agencies maintained by the awardee for the purpose of securing business.
(13) Gratuities. The funding agreement may be terminated by the Government if any gratuities have been offered to any representative of the Government to secure the award.
(14) Patent Infringement. The awardee must report each notice or claim of patent infringement based on the performance of the funding agreement.
(15) American Made Equipment and Products. When purchasing equipment or a product under the SBIR funding agreement, purchase only American-made items whenever possible.

5.02 Reports

Three copies of a final report on the Phase 1 project shall be submitted to NIST within 30 calendar days after completion of the 6-month Phase 1 period of performance. The final report shall include a single-page project summary as the first page, identifying the purpose of the research, and giving a brief description of the research carried out, the research findings or results, and the commercial applications of the research in a final paragraph. The remainder of the report should indicate in detail the research objectives, research work carried out, results obtained, and estimates of technical feasibility.

All final reports must carry an acknowledgment on the cover page such as: "This material is based upon work supported by the National Institute of Standards and Technology (NIST) under contract, grant, or cooperative number___________. Any opinions, findings, conclusions or recommendations expressed in this publication are those of the author(s) and do not necessarily reflect the views of NIST."

5.03 Payment Schedule

The specific payment schedule (including payment amounts) for each award will be incorporated into the contract.

No advance payments will be allowed.

NIST will allow the Phase 1 award amount to be paid on a bimonthly interim basis upon delivery and acceptance of three progress reports that describe services performed, and one final payment upon delivery and acceptance of the final report. Likewise, NIST will allow the Phase 2 award amount to be paid on a periodic interim basis upon delivery and acceptance of four progress reports that describe services performed, and one final payment upon delivery of the final report.

5.04 Proprietary Information, Inventions, and Patents

5.04.01 Limited Rights Information and Data

Information contained in unsuccessful proposals will remain the property of the offeror. Any proposal which is funded will not be made available to the public, except for the "Project Summary" page.

The inclusion of proprietary information is discouraged unless it is necessary for the proper evaluation of the proposal.

Information contained in unsuccessful proposals will remain the property of the offeror. The Government may, however, retain copies of all proposals. Public release of information in any proposal submitted will be subject to existing statutory and regulatory requirements. If proprietary information is provided by an applicant in a proposal, which constitutes a trade secret, proprietary commercial or financial information, confidential personal information or data affecting the national security, it will be treated in confidence, to the extent permitted by law. This information must be clearly marked by the applicant with the term "confidential proprietary information" and the following legend must appear on the title page of the proposal:

> "These data shall not be disclosed outside the Government and shall not be duplicated, used, or disclosed in whole or in part for any purpose other than evaluation of this proposal. If a funding agreement is awarded to this applicant as a result of or in connection with the submission of these data, the Government shall have the right to duplicate, use, or disclose the data to the extent provided in the funding agreement and pursuant to applicable law. This restriction does not limit the Government's right to use information

> contained in the data if it is obtained from another source without restriction. The data subject to this restriction are contained on pages ____ of this proposal."

Any other legend may be unacceptable to the Government and may constitute grounds for removing the proposal from further consideration, without assuming any liability for inadvertent disclosure. The Government will limit dissemination of such information to within official channels."

5.04.02 Copyrights

The contractor may normally establish claim to copyright any written material first produced in the performance of an SBIR contract. If a claim to copyright is made, the contractor shall affix the applicable copyright notice of 17 U.S.C. 401 or 402 and acknowledgment of Government sponsorship (including funding agreement number) to the material when delivered to the Government, as well as when the written material or data are published or deposited for registration as a published work in the US Copyright Office. For other than computer software, the contractor gives to the Government, and others acting on its behalf, a paid-up, nonexclusive, irrevocable, worldwide license to reproduce, prepare derivative works, distribute copies to the public, and perform publicly and display publicly, by or on behalf of the Government.

For computer software, the contractor gives to the Government a paid-up, nonexclusive, irrevocable, worldwide license for all such computer software to reproduce, prepare derivative works, and perform publicly and display publicly, by or on behalf of the Government.

5.04.03 Data Rights

Except for copyrighted data, the Government shall normally have unlimited rights in:

(a) data specifically identified in the SBIR funding agreement to be delivered without restriction;

(b) form, fit, and function data delivered under the funding agreement;

(c) data delivered under the funding agreement that constitute manuals or instructions and training material for installation, operation, or routine maintenance and repair of items, components, or processes delivered or furnished for use under the funding agreement; and

(d) all other data delivered under the funding agreement unless identified as SBIR data.

According to Federal Acquisition Regulation 52.227-20, Rights and Data - SBIR Program (March 1994), the awardee is authorized to affix the following "SBIR Rights Notice" to SBIR data delivered under the funding agreement:

SBIR RIGHTS NOTICE

These SBIR data are furnished with SBIR rights under Contract No.____________ (and subagreement _________________, if appropriate). For a period of 4 years after acceptance of all items to be delivered under this award, the Government agrees to use these data for Government purposes only, and they shall not be disclosed outside the Government (including disclosure for procurement purposes) during such period without permission of the awardee, except that, subject to the forgoing use and disclosure prohibitions, such data may be disclosed for use by support contractors. After the aforesaid 4-year period, the Government has a royalty-free license to use, and to authorize others to use on its behalf, these data for Government purposes, but is relieved of all disclosure prohibitions and assumes no liability for unauthorized use of these data by third parties. This Notice shall be affixed to any reproductions of these data, in whole or in part.

(END OF NOTICE)

The Government's sole obligation with respect to any properly identified SBIR data shall be as set forth in the paragraph above.

5.04.04 Patents

Small business concerns normally may retain the principal worldwide patent rights to any invention developed with Government support. The Government receives a royalty free license for Federal Government use, reserves the right to require the patent holder to license others in certain circumstances, and requires that anyone exclusively licensed to sell the invention in the United States must normally manufacture it domestically. To the extent authorized by 35U.S.C. 205, the Government will not make public any information disclosing a Government supported invention for a minimum 4-year period (that may be extended by subsequent SBIR funding agreements) to allow the awardee a reasonable time to pursue a patent.

5.04.05 Invention Reporting

SBIR awardees must report inventions to the NIST SBIR Program within 2 months of the inventor’s report to the awardee. The reporting of inventions may be accomplished by submitting paper documentation, including fax. In the future, it may be required that invention reporting be accomplished by electronic submission to a federal database, iEdison.

5.05 Additional Information

(1) This program solicitation is intended for informational purposes and reflects current planning. If there is any inconsistency between the information contained herein and the terms of any resulting SBIR funding agreement, the terms of the funding agreement are controlling.

(2) Before award of an SBIR funding agreement, the Government may request the offeror to submit certain organizational, management, personnel, and financial information to assure responsibility of the applicant.

(3) The Government is not responsible for any monies expended by the applicant before award of any funding agreement.

(4) This program solicitation is not an offer by the Government and does not obligate the Government to make any specific number of awards. Also, awards under the SBIR Program are contingent upon the availability of funds.

(5) The SBIR Program is not a substitute for existing unsolicited proposal mechanisms. Unsolicited proposals must not be accepted under the SBIR Program in either Phase 1 or Phase 2.

(6) If an award is made pursuant to a proposal submitted under this SBIR Program solicitation, a representative of the contractor will be required to certify that the concern has not previously been, nor is currently being, paid for essentially equivalent work by any Federal agency.

(7) The responsibility for the performance of the principal investigator, and other employees or consultants who carry out the proposed work, lies with the management of the organization receiving an award.

(8) Cost-sharing is permitted for proposals under this program solicitation; however, cost-sharing is not required. Cost-sharing will not be an evaluation factor in consideration of your Phase I proposal.

5.06 Research Projects with Human Subjects, Human Tissue, Data or Recordings Involving Human Subjects

Any proposal that includes research involving human subjects, human tissue, data or recordings involving human subjects must meet the requirements of the Common Rule for the Protection of Human Subjects, codified for the Department of Commerce at 15 CFR Part 27. In addition, any proposal that includes such research on these topics must be in compliance with any statutory requirements imposed upon NIH and other federal agencies regarding these topics, all regulatory policies and guidance adopted by NIH, FDA, and other federal agencies on these topics, and all Presidential statements of policy on these topics. Any questions regarding these requirements should be addressed to Melissa Lieberman at (301) 975-4783 or melissa.lieberman@nist.gov.

IRB Education Documentation. A signed and dated letter is required from the Organizational Official who is authorized to enter into commitments on behalf of the organization documenting that appropriate IRB education has been received by the Organizational Official, the IRB Coordinator or such person that coordinates the IRB documents and materials if such a person exists, the IRB Chairperson, all IRB members and all key personnel associated with the proposal. The NIST requirement of documentation of education is consistent with NIH notice OD-00-039 (June 5, 2000). Although NIST will not endorse an educational curriculum, there are several curricula that are available to organizations and investigators which may be found at: http://grants.nih.gov/grants/guide/notice-files/NOT-OD-00-039.html.

5.07 Research Projects Involving Vertebrate Animals

Any proposal that includes research involving vertebrate animals (including fish) must be in compliance with the National Research Council's "Guide for the Care and Use of Laboratory Animals" which can be obtained from National Academy Press, 2101 Constitution Avenue, NW, Washington, D.C. 20055. In addition, such proposals must meet the requirements of the Animal Welfare Act (7 U.S.C. 2131 et seq.), 9 CFR Parts 1, 2, and 3, and if appropriate, 21 CFR Part 58. These regulations do not apply to proposed research using pre-existing images of animals or to research plans that do not include live animals that are being cared for, euthanized, or used by the project participants to accomplish research goals, teaching, or testing. These regulations also do not apply to obtaining animal materials from commercial processors of animal products or to animal cell lines or tissues from tissue banks.

6.0 SUBMISSION OF PROPOSALS

6.01 Deadline for Proposals

Deadline for Phase 1 proposal receipt (4 copies) at the address below is 3:00 pm on January 28, 2005 at the Contracts Office address below. NIST does not accept electronic submission of proposals.

All Offerors should expect delay in delivery due to added security at NIST. It is the responsibility of the Offeror to make sure delivery is made on time.

Because of the heightened security at NIST, FED-EX, UPS or similar-type service is the preferred method of delivery of proposals.

If proposals are to be hand delivered, delivery must be made on the actual deadline date and a 24-hour notice must be made to the NIST Contracts Office prior to delivery. All Offerors must notify Lisa Wells at 301-975-8171, or Michael Szwed at 301-975-6330. The name of the individual or courier company making the delivery must be included in the notification.

NIST assumes no responsibility for evaluating proposals received after the stated deadline or that do not adhere to the other requirements of this solicitation (see checklist in Section 8.04).

Federal Acquisition Regulation (FAR 52 215-1) regarding late proposals shall apply.

Offerors are cautioned to be careful of unforeseen delays, which can cause late arrival of proposals at NIST, resulting in them not being included in the evaluation procedures. No information on the status of proposals under scientific/technical evaluation will be available until formal notification is made.

6.02 Proposal Submission

Submission of Proposal Packages as defined in section 3.3 should be sent in 4 copies to:

National Institute of Standards and Technology
Acquisition Management Division
Attn: Lisa Wells, NIST–05-SBIR
100 Bureau Drive STOP 1640
Building 301, Room B129
Gaithersburg, MD 20899-1640

Phone Number: (301) 975- 8171

Photocopies will be accepted. All signatures in each of the four copies MUST be ORIGINAL, i.e. no photocopies of signatures will be accepted.

Acknowledgment of receipt of a proposal by NIST will be made. Evaluation of proposals and award of contracts will be expedited, but no information on proposal status will be available until the final selection is made. However, contracting officers may contact any and all qualified offerors prior to contract award. Selections are posted on the NIST SBIR website approximately six months after the solicitation close date.

(a) Packaging--Secure packaging is mandatory. NIST cannot process proposals damaged in transit. All 4 copies of the proposal must be sent in the same package. Do not send separate "information copies," or several packages containing parts of a single proposal, or two packages of 4 copies of the same proposal

(b) Bindings--Do not use special bindings or covers. Staple the pages in the upper left hand corner of each proposal. Separation or loss of proposal pages cannot be the responsibility of NIST.

7.0 SCIENTIFIC AND TECHNICAL INFORMATION SOURCES

Background information related to the NIST research programs referenced within the subtopics may be found within the NIST website at: www.nist.gov. Wherever possible, reference citations are provided within the individual subtopics.

8.0 SUBMISSION FORMS AND CERTIFICATIONS

8.01 Click on this link: **Cover Sheet** in order to download the required form (2 pages) in pdf format.

8.02 Click on this link: **Project Summary** in order to download the required form in pdf format.

8.03 Click on this link: **Proposed Budget** in order to download the required form in pdf format.

8.04 Checklist of Requirements

Please review this checklist carefully to assure that your proposal meets the NIST requirements. All signatures in the three required forms MUST be original. No photocopies of signatures will be accepted. Failure to meet these screening requirements will result in your proposal being returned without consideration. Four copies of the proposal must be received by 3:00p.m. EST January 28, 2005.

1. The COVER SHEET downloadable form (both pages combined) has been completed and is PAGE 1 of the proposal. Instructions for completing the Cover Sheet form may be found in Section 3.03.01.
2. The PROJECT SUMMARY downloadable form has been completed and is PAGE 2 of the proposal. Instructions for completing the Project Summary form may be found in Section 3.03.02.
3. The TECHNICAL CONTENT of the proposal begins as PAGE 3 and includes the items identified in Section 3.03.3 of the solicitation. The technical content section of the proposal is limited to 22 pages in length.

4. The PROPOSED BUDGET downloadable form has been completed and is the LAST PAGE of the proposal. Instructions for completing the Proposed Budget form may be found in Section 3.03.04. The proposal budget is for $75,000 or LESS
5. The proposal is limited to only ONE of the subtopics in Section 9.
6. The abstract contains no proprietary information and does not exceed space provided on the Project Summary.
7. The proposal contains only pages of 21.6cm X 27.9cm size (8 ½" X 11") and is bound by a single staple on the upper left corner.
8. The proposal contains an easy-to-read font (fixed pitch of 12 or fewer characters per inch or proportional font of point size 10 or larger) with no more than 6 lines per inch, except as a legend on reduced drawings, but not tables.
9. The P.I. is employed by the company.

NOTE: Offerors are cautioned to be careful of unforeseen delays that can cause late arrival of proposals, with the result that they WILL not be forwarded for evaluation.

9.0 TOPIC AREAS

9.01 Advanced Biological and Chemical Sensing Technologies

9.01.1-3 Instrument for Characterization of Environmental Soot

Particulate matter in the environment is known to have a significant influence on the climate, air quality, and population health. We are currently developing a suite of prototype, chemically engineered, carbonaceous-based particulate materials, which simulates targeted properties of particulate matter found in the environment. Of special interest is to use laser-induced incandescence (LII) to provide quantitative information on particle primary size and volume fraction for the engineered soot to be prepared in our facility. A turn-key system is sought that will provide real-time, non-intrusive measurements of soot primary size in the range of 10 nm – 100 nm, high sensitivity to low volume fraction (concentration) of better than 0.5 parts per billion (i.e., less than 1 microgram per cubic meter), concentrations as high as 10 parts per million (19 grams per cubic meter). In addition to particle primary size, aggregate/agglomerate size needs to be characterized (e.g., via the fractal dimension) for particles as large as 10 microns. The software must provide distributions of particle size (primary and aggregate) and volume fraction, access to the individual particle characteristics so that post processing of statistical information and graphing of data can be carried out on other computing platforms.

Phase 1 should demonstrate the feasibility of the LII diagnostic to meet the stated criteria. The objective of Phase 2 is the delivery of a functioning LII instrument. It is expected that this new measurement capability will find immediate commercial applications for a wide range of environmental and combustion-related technologies.

NIST is willing to collaborate with awardee(s).

9.02 Analytical Methods

9.02.1-5 Analytical Method for Quantifying the Water Vapor Transmission Rate of Woven Fabrics

The environmental degradation of ballistic fibers used in protective vests has become an area of concern, with the apparent premature failure of at least one vest during use. In response to a directive issued by U.S. Attorney General Aschroft, OLES at NIST has initiated a research program to quantify the impact of certain environmental exposures and mechanical deformations on the long-term performance of ballistic body armor. One aspect of this research program focuses on how moisture degrades the performance characteristics of ballistic fibers. An essential element of this research is the transmission rate of moisture, i.e., water vapor transmission rate (WVTR), through the woven fabric that forms the outer covering of the ballistic body armor.

Since there is no analytical instrument on the market that is capable of measuring the WVTR of woven fabrics, we are soliciting proposals for the design and construction of a prototype instrument that accurately measures this parameter in a reproducible manner. The main technological challenge involves the development of an approach and instrument that minimizes the loss of water vapor at the specimen edge. By doing so, the measured transmission rate will accurately reflect the permeability of the panel covering. This technology will then be used to assess the effect that moisture has on ballistic fiber degradation.

Body armor manufacturers currently build armor to a ballistic-resistance standard; however, that standard does not address the long-term performance of body armor, especially degradation in performance due to environmental factors. Advancement of the technology to measure water vapor transmission rates is an important step toward addressing this deficiency.

For Phase 1, the design, construction and delivery of a working prototype that accurately measures the WVTR of woven fabrics used in ballistic applications. For Phase 2, the deliverables will be the perfection of the design, determination of the lab-to-lab variability of the instrument, and assessment of its feasibility as a standard metric in the design criteria of ballistic body armor.

NIST is willing to work collaboratively with the awardee to help with evaluation of the operating parameters.

9.02.2-1 Adiabatic Demagnetization Refrigerator Precision Controller for X-ray Microanalysis

NIST is a world leader in the development of superconducting transition edge sensors and SQUID amplifiers for ultra-high-resolution x-ray spectroscopy for the semiconductor industry. These microanalysis systems will enable the detection and elemental analysis of nanoscale particle contaminants in integrated circuit production. In order for such systems to provide near real time analysis, the stability of the system is of paramount importance. The temperature stability of the ADR (Adiabatic Demagnetization Refrigerator) used to cool the sensor is key for maintaining x-ray line positions.

Proposals are solicited for systems to control the ADR temperature with the stability required for the microanalysis system. Stability will need to be to the 1 micro-Kelvin rms level in a 1Hz bandwidth with longer-term drifts of no more than 10 micro-Kelvin in 10 hours. The system will need to be cheap to manufacture, compact, and easy-to-use, but reliable in operation. The system will need to include electronics for measuring a suitable 50-100 mK thermometer(s), a hardware or software PID system for temperature control, and a current source for the ADR magnet. The source will need to provide up to 10 A for complete temperature cycling while also being able to regulate to the accuracy specified above at temperatures of 50-100 mK. Commercial subcomponents are acceptable, but the cost of the overall system must be kept low. The ADR Precision Controller (ADRPC) will also automate the temperature cycling of the ADR and the recording of housekeeping/diagnostic data on its performance.

NIST will provide technical details of the ADR and temperature regulation system presently in use.

Phase 1 deliverable will be a beta level systems for evaluation and test on NIST micro-analysis system. Phase 2 will be the delivery and test of a production version of the ADR precision controller on a microanalysis system at NIST. It is expected that NIST will collaborate extensively with awardee(s).

Reference:

High-Resolution, Energy-Dispersive Microcalorimeter Spectrometer for X-Ray Microanalysis, Wollman, D.A.; Irwin, K.D.; Hilton, G.C.; Dulcie, L.L.; Newbury, D.E.; Martinis, J.M., J. Microscopy 188(3): 196-223, Dec 1997.

9.02.3-5 Multi-element Forward Scatter Detector for an FE-SEM/EBSD System

The field emission scanning electron microscope (FE-SEM) in normal operation provides the capability of viewing surface features via secondary electrons (SE). Also available are backscattered electrons (BSE) which provide additional information on both surface topography and relative elemental composition of different surface features. Another technique utilizing electrons diffracted near the surfaces of crystals called electron backscatter diffraction (EBSD) provides quantitative crystallographic information about the sample. For this technique, the sample is tilted through a large angle, typically 70 degrees, and the diffraction patterns captured by a camera system placed within a few centimeters of the inclined sample surface. The diffracted electrons are incident on a round phosphor which converts the electrons to photons for imaging by a CCD camera. Recently, interest in another observational technique called electron channeling contrast imaging (ECCI) has increased. The technique makes use of electron channeling patterns for precise orientation determination, in either a backscatter or forward scatter configuration. With the ECCI method it is possible to image defects such as dislocations lying close to the crystal surface. The defect contrast in the image arises due to differing numbers of electrons scattered in certain crystallographic directions compared to a perfect crystal. In order to fully characterize dislocations using the ECCI technique, crystalline samples must be rotated about the sample normal into specific incident beam diffraction conditions, or alternatively, different segments of the electron detector may be individually addressed to quantify electron scattering out of the sample.

One limitation of the ECCI technique in a backscatter configuration is the lateral resolution due to spreading of the near normal incident electron beam in the sample, which is at best the same as that obtained in BSE imaging, approximately 100 nm.

Images obtained from electrons that are forward scattered from shallow depths in samples oriented at the high angle used in EBSD will have better lateral resolution. Lateral resolution in EBSD maps can be as good as 10 nm. Presently there are forward scatter detectors commercially available. These detectors usually comprise one or two small silicon diodes attached to the bottom of the EBSD assembly. Dislocation images have been obtained using such detectors but there is little control over the crystalline orientation of the sample relative to the detectors other than by rotation about the sample normal. Since most defects will not be located exactly on this axis, manual rotation can be very tedious to achieve the desired orientation since the area of interest moves out of the field of view very quickly even at moderate SEM magnifications, e.g., 20kX or higher. To alleviate some of this tedium we propose an array of silicon-diodes arranged through at least 90 degrees along the bottom half perimeter of the EBSD assembly with the capability of individually accessing the signal output from any single detector or combination of detectors. This would allow many different diffracting conditions to be imaged without the necessity of rotating the sample and therefore defects could be easily properly characterized. For this purpose NIST seeks design, construction, and delivery of such a detector array, consisting of at least fifteen (15) isolated, individually addressable silicon diode chips located on the bottom half perimeter of our present EBSD camera housing. Alternatively, an integrated semi-annular detector assembly consisting of an even greater number of individually addressable detectors fabricated by, for example photolithography, would provide more precise control yet. The detector array must be centered on the bottom of the EBSD housing. Each of the detector chips would be individually addressable through a computer interface. Multiple chips might also be addressed simultaneously for purposes of mathematically combining signals. The output must be amplified with gain and black level controls and presented to the input of the SEM signal processor. The chips/electronics should be capable of operating at a minimum of one frame per 30 seconds. The wiring for the chips must use the available vacuum conduit associated with the EBSD camera assembly and move in and out with the camera. The array must be located on the EBSD assembly in such a manner as to not interfere with the normal high tilt requirements of the EBSD. For an integrated semi-annular assembly, the radial width will be approximately one centimeter, and similarly not interfere with the EBSD tilt requirements. It is also desired to have either a virtual image of the chip array superposed on the EBSD pattern for purposes of associating the selected signal with a certain diffraction condition, or a precisely angularly calibrated placement of an integrated assembly.

The awardee(s) will need to deliver a prototype multi-element forward scatter detector for implementation onto the NIST FE-SEM. This item will be deliverable at the end of the Phase 1 project.

The awardee(s) will need to deliver system controls, computer-based or other, for implementation onto the NIST FE-SEM. This item will be deliverable at the end of the Phase 2 project.

NIST intends to retain the system and controls after termination of the contract.

NIST anticipates a small amount of collaboration in order to clarify certain system details and requirements for our particular FE-SEM. We do not anticipate developing any hardware or controls at NIST.

The awardee(s) may need access to the NIST FE-SEM lab in order to measure dimensions for incorporation of the detector into the microscope.

9.03 Healthcare and Medical Physics

9.03.1-5 An Optical Coherence/Multi-photon Fluorescence Microscope for Imaging of Tissue Engineered Medical Products (TEMPs)

Regenerative medicine is an emerging, interdisciplinary field which is full of promise for those in need of organ and tissue replacement and repair. The high investment costs involved in the areas of research and development of TEMPs and the extensive time required to obtain regulatory approval have limited the widespread commercial utilization of these materials. The development of new materials, production engineering techniques, and metrologies that can speed the TEMP to market is highly desirable. A significant difficulty in furthering the understanding of the cell/scaffold interaction is the lack of a high-resolution, non-destructive imaging technique that is capable of penetrating deeply into the highly-scattering scaffold medium.

We are soliciting proposals for the design and construction of a prototype microscope for dual structure/function, 3D imaging of TEMPs. This microscope will perform simultaneous optical coherence microscopy (OCM) and multi-photon fluorescence microscopy (MPM) through the use of a pulsed, mode-locked, titanium sapphire laser source. Two-dimensional images will be obtained by x,y beam scanning. A 3-dimensional image set will be constructed by using a high resolution translation stage to step either the objective or sample in z. The sensitivity of the OCM channel should be >110 dB and designed for a minimum axial resolution of 3-4 mm with a 0.9 NA, water immersion objective. The minimum pixel rate should be 10 kHz. A software controlled or otherwise automated focus tracking strategy will be employed for imaging into the sample. A fiber-optic based OCM should be considered before designing for open-air optics. Lastly, an eyepiece and white light source shall be included to allow for sample alignment.

The deliverables for Phase 1 are a preliminary design of the instrument including a strategy for modulation, detection, and focus tracking for 3D scanning. In addition, identification of potential hurdles in building the instrument should be made and alternate approaches proposed.

For Phase 2, the deliverables are:

1. OCM modulator, microscope scan head and focus tracking system.

2. Demonstrated simultaneous OCM and MPM imaging from constructed prototype instrument.

3. A record of OCM and MPM baseline imaging performance: resolution, sensitivity, imaging rate.

4. Optical train design.

5. Software source code to control instrument, acquire and save images.

6. List of components, including manufacturer and model number.

7. Design specifications of any custom electronics.

Note that a complete prototype instrument is not requested as a deliverable because of the cost prohibitive nature of the laser source. The OCM modulator, optical scan head and focus tracking system will be retained by NIST.

NIST anticipates working collaboratively with the awardee(s) on a consistent basis to answer questions and provide guidance. The awardee(s) may require the use of NIST instrumentation. There are several Ti:Saph lasers on the NIST site which could be used for testing, if necessary.

References:

Dunkers, J. D., Cicerone, M. T., and Washburn, N. R., "Collinear Optical Coherence and Confocal Fluorescence Microscopies for Tissue Engineering", Optics Express 2003; 11(23): 3074-3079.

Beaurepaire, E., Moreaux, L., Amblard, F., and Mertz, J. "Combined Scanning Optical Coherence and Two-photon-excited Fluorescence Microscopy", Optics Letters 1999, 24(14): 969-971.

9.04 Homeland Security

9.04.1-2 Wireless Smart Sensor Network with Localization Capability

Wireless network smart sensors play a very important role in homeland security and first responder (HLS-FR) applications. A smart sensor can reduce a large amount of data measured from a single sensor, a cluster of sensors, or an array of sensors to simple, human readable information for quick decision-making. Without the need to lay many long cables, these wireless sensors can be easily deployed for surveillance and monitoring environmental and hazardous conditions. Integrated with networking capability, these wireless sensors can be linked to form a wireless sensor network that can pass and exchange data among sensors and to the Internet for easy access with a common web browser. The activity of a malfunctioned or damaged sensor can be quickly taken over by the adjacent sensors. In some specific HLS-FR applications, it is desirable to have a wireless smart sensor that can report its location inside and outside a building or in a moving vehicle, container, or vessel with accuracy as small as thirty centimeters. The wireless smart sensor could use the latest GPS, differential GPS, or other advanced localization techniques or technologies to identify its location.

NIST is conducting research and development work on communication and connectivity standards for smart and wireless sensors for HLS-FR applications. We are currently working with IEEE and industry to standardize wireless communication interfaces for networking smart sensors. Hence, we are soliciting proposals for the development of a wireless sensor network that has localization capability, operating both indoor and outdoor. A node of the wireless sensor network, where sensors or actuators can be connected, is defined as the wireless Transducer Interface Module

(TIM). Each TIM must have at least 500 Kbytes of memory space available for developing smart sensor application programs by the user. The wireless TIMs should be designed for compatibility with the IEEE 1451 family of standards. It is recommended that the proposing party be thoroughly familiar with IEEE 1451. Copies of the standards can be acquired from IEEE at 1-800-678-4333. The awardee(s) might need detailed information about the IEEE 1451 standards and their implementations developed at NIST..

The expected Phase 1 result is the delivery of three units of wireless TIMs with early demonstration capability showing concepts of sensor localization indoor and outdoor, wireless networking, IEEE 1451.x TEDS, etc. The network and TIMs would be retained by NIST, with the understanding that the contractor would be provided access to the equipment if successful in receiving a Phase 2 award. It is expected that a Phase 2 effort will result in the construction and demonstration of a full-function prototype suitable for commercialization.

9.04.2-4 Development of Field Detectors for Radiological Measurements

The potential of terrorist activities both within the United States and abroad have focused attention on the level of our preparedness to deal with large-scale radiological, chemical and biological threats. These events make it clear that issues involving radiation and radioactive materials must be addressed in proper emergency response plans prepared to address terrorist threats. The full spectrum of radiological threats from terrorists span the deliberate dispersal of radioactive material to the detonation of a nuclear weapon. While the most likely threat is the dispersal of radioactive materials, the use of a crude nuclear weapon against a major city cannot be dismissed. Early detection of terrorist activities involving radioactive materials as well as radiation safety guidance for emergency planners and emergency responders, including those responsible for restoring the disaster area, are also a primary issue to prevent and detect future attacks. The early detection of terrorist activities involves the capability of measuring trace level amounts of radioactive materials found in places where these materials are handled or transported. In the assembly of nuclear weapons the detection of uranium and plutonium is mandatory. For preventing the dispersal of radioactive materials, which is the threat posed by “dirty bombs”, the requirements for monitoring the handling of radioactive sources is a more difficult task. Due to the variety of radioactive source use in industrial and medical applications all around the world. Cobalt-60, Cesium-137, Thulium-170, Iridium-192, Iodine-125, Technetium-99, Americium-241 and Radium-226 are some of a long list of radioactive materials used in many everyday applications. Efforts are needed in the development of new field detectors. In particular for handheld detectors for first responders and large area detectors for detection of radioactive source in moving vehicles. Proposals submitted under this subtopic may address access to NIST facilities and staff.

A working prototype is expected at the end of phase 1. The prototype will be retained by NIST unless a phase 2 proposal is successful, in which case the contractor may have access to the prototype for further development. If phase 2 is successful, the ultimate device will be retained at NIST (if not, the prototype will be returned to NIST).

9.05 Information Technology

9.05.1-9 Sensor Infrastructure for Multi Modal Interfaces and Smart Spaces

The NIST Smart Space and Meeting Room projects serve a research and development community investigating the numerous technical issues that must be resolved to before we can create viable multimodal audiovisual computer interfaces. Among the key elements of this research are acoustic sensor arrays. But it is certain advances in acoustic processing techniques are needed in order to bring spoken/visual interfaces to practical usability levels. Key problems in research and development of effective multiple microphone techniques include:

· Beamforming in the near field, far field, and in multiple geometries

· Source localization in support of signal enhancement and sensor fusion experiments

· Source separation, both directionally and blind, to deal with simultaneous speakers

· Enhancing audio quality for speech recognition, which may include array processing or other signal processing techniques

The existing NIST Mk-III Microphone Array provides an extensible processing architecture with a fully networked sensor platform with sixty-four channels of analog to digital conversion per motherboard. These can be slaved to a master clock for larger sensor counts. These array boards are fabricated by local Contract Electronic Manufacturers (CEMs). Moreover, it may stimulate local manufacturing capabilities if large-scale product runs are made. It is being deployed in the next generation NIST Meeting Room to develop large-scale test data sets for phased array processing algorithms, and speech recognition experiments.

However, its current form offers only a linear geometry; which is an important baseline, but which exhibits spatial ambiguities as the source moves towards the endfire bearings. Other geometries and algorithmic approaches to beamforming are desirable, and may use multiple arrays, random placement microphones, such as table top microphones, circular geometries, or entirely different ones. Future generation Meeting Room enhancements may use these developments, if successful, to create advanced reference data for our research communities.

The awardee(s) is expected to provide statistical signal processing algorithms, associated computer codes, and possibly hardware prototypes to be derived from the NIST Mk-III microphone array platform.

Required Checklist

NIST anticipates working collaboratively with the awardee(s) to export the NIST software and hardware base to the awardee(s). Then we will work collaboratively to test and evaluate the resulting algorithms and hardware.

Awardee(s) will need access to the NIST Mk-III sensor array design data and to the NIST group which will fabricate the hardware. There will probably be site visits by the awardee(s).

9.05.2-4 High Efficiency Low Dark Count InGaAs Detector for IR Photon Counting

Photon counting in the infrared is currently a difficult task, but of pressing interest for emerging quantum information applications. The most commercially advanced detector in this region is the InGaAs avalanche photodiode (APD), which, as currently available, has low detection efficiency (~10 to 30%), significant afterpulsing requiring long dead time, and high dark count rates (~50K/s) requiring gated biasing for practical operation. Even the continued manufacture of this detector, with its shortcomings, is uncertain. It is critical for the emerging applications that additional sources and improved versions of these detectors be encouraged. Some of the detector deficiencies are due to the fact that they are not specifically designed for photon counting. An InGaAs detector optimized for photon counting should go a long way to improving on each of these deficiencies. (While other detectors are possible for photon counting at 1.5 micrometers, their applicability to quantum information applications is limited due to large size, cryogenic requirements, timing jitter, and/or cost.) NIST seeks the development of an IR detector optimized for photon counting at a wavelength of 1.5 micrometers (an InGaAs APD is expected, but another detector meeting the same characteristics and final form factor, including any necessary cooling apparatus, will also be considered). The design goal should be for a detector with a detection efficiency of 60% or greater and dark count rate of less than 1000 cts/s. The detector should be capable of operating at count rates of more than 1 MHz with dead time less than 1 microsecond. For the intended applications, timing is critical, so the timing jitter of the detector output relative to the input pulse should be less than 1 nanosecond. The detector design should be practical enough that the ultimate cost of detectors should be comparable to existing InGaAs APDs. An additional practicality requirement is that the design should be robust with a mean time between failure of 10,000 hrs or greater.

Awardee will provide a minimum of 10 detector samples to NIST which will become property of NIST at the conclusion of the phase 1 work.

Though not necessary, NIST would consider working collaboratively with the awardee to help with evaluation of the operating parameters.

9.05.3-9 Cross-Layer Design for Mobile Ad hoc Networks

Mobile ad-hoc networks, which can be rapidly deployed anywhere at any time, play a crucial role in homeland security and first responder applications. The main drawback of these networks is maintaining link connectivity for multimedia streaming. In order to provide robust and efficient delivery of real-time multimedia information under disaster circumstances, cross-layer design and optimization is becoming a viable approach to improve network reliability. The concept of the cross layer design relies on the interaction amongst different layers such as application, routing, media access control (MAC), and the physical layer. Although this concept can be employed in all communication networks, it is especially attractive for wireless multihop ad-hoc networks where the network topology changes dynamically.

NIST is soliciting proposals to develop a mobile ad hoc network platform for real-time communication applications, which allows the underlying technology of each layer to adopt itself to the changes of the network characteristics. For the Phase 1, the objective is to develop a cross-layer optimizer that jointly optimizes multidimensional tradeoff issues such as rate, delay, distortion, and transmitter power level constrained by a dynamically changing network topology. As part of this phase proof of concept, a plan to lay down the groundwork for developing an infrastructure testbed for higher network utilization would be essential. Thus, phase 2 requires using this framework to implement a prototype system that can demonstrate the effectiveness of the candidate cross layer optimizer. In the prototype system IEEE 802.11 may be considered as the reference technology. During the course of this project NIST personnel will be available for technical discussions and possible collaboration with the awardee.

9.05.4-9 Removing Superfluous Functions from COTS Executables

Critical infrastructure, defense projects, and even weapons systems increasingly include commercial, off-the-shelf (COTS) software. COTS software typically is not as trustworthy as desired. A vulnerability that is insignificant in a commercial setting may be a major risk in a high-assurance setting. Therefore COTS software should be carefully examined to reduce the chance of accidental or deliberate vulnerabilities. Such examinations are expensive, and the cost increases faster than the size of the software. Since COTS software typically has many functions, options, and features that are not needed for the particular high-assurance in which it is used, a tool to remove unneeded behaviors, symbols, aspects or code would be very useful.

A simplifier tool could operate either on machine language level executables or the slightly higher level “byte code”. (It is unlikely that many COTS packages would be delivered as source code.) Dead or unreachable code, tables, images, etc. could be removed without human intervention (“dead-code stripping”). Outputs or inputs that are not used, such as data dumps or alternate input formats, might be straightforward to specify, locate, and remove. Optional features, such as Internet access, are harder to specify and likely consists of many blocks of code that are more challenging to identify and remove.

Although finding and removing every superfluous bit in every program is undecidable, many products demonstrate it is feasible and even beneficial. In Apple Computer’s Xcode™, “the static linker (ld) supports the removal of unused code and data blocks from executable files.” PETrim, from Bitsum Technologies (Johnson City, TN), “trims portable executables by realigning, restructuring, and stripping unnecessary data.”

Any proposal should begin with a survey of available tools and technologies. This is not a thorough evaluation of everything existent. Rather it is a search to get a better idea of the state of the art.

The main effort of a Phase 1 project is a plan for the incremental development of a tool along with a software architecture and validation methods. Different approaches are possible. For example, a tool that traces executions and helps a human analyst simplify the code could be helpful. The tool could instead or in addition use traces of test executions: if code is used in a realistic test case, it might be ignored as a candidate for removal. Similar to how some advanced virus scanners work, a simplifier could scan the executable to map out what might be executed and under what inputs.

NIST is constantly involved in evaluating or directing the evaluation of software. NIST is embarking on a significant project working with DHS to evaluate tools. A simplifier would be significant. This tool has commercial potential beyond high assurance. Software producers or users can use a simplifier to shrink software packages, letting them load and run faster.

An algorithm model is expected to be delivered under Phase 1 and executable code in Phase 2.

9.05.5-9 Multi-user Collaborative Tools for Immersive Scientific Visualization

Scientific discovery in immersive visualization environments (VEs) is impeded by a lack of support for simultaneous multi-user interactive collaboration. We solicit tools that enable spatially separated researchers to participate in the same VE at the same time, allowing them to observe and interact with both the visualization data and the other participants. The immediate benefit of these tools is that the scientific discovery process can be accelerated, at a potentially lower cost, though the collaboration of scientists regardless of their physical location.

The tool capabilities that we solicit should provide the following capabilities:

(1) Allow participants to load, unload, manipulate and query objects in the VE, and cause changes made to the VE by one participant to be seen by all other participants.

(2) Allow participants to enter and leave the VE at any time, and to implement graphical objects which represent the position and identity of other participants in the VE.

Requirements for this proposal include:

(1) Software should be based on the open source immersive visualization system DIVERSE (diverse.sourceforge.org), using its DPF and DTK modules.

(2) Software should run on all systems supported by the DIVERSE DPF module.

(3) Software should not require any special-purpose hardware.

(4) The communications between the visualization systems must be based on DIVERSE networked shared memory and message passing.

(5) Software must be encapsulated as DIVERSE DSOs, allowing them to be dynamically loaded into any DIVERSE application while the application is running.

(6) X-windows based applications will be used in the virtual environment to control the behavior of the collaborative software, in both immersive and desktop systems.

(7) The final software should operate securely across the internet connecting different facilities

For an SBIR Phase 1, deliverables should include:

(1) The design of a framework that extends DIVERSE and brings a new range of simultaneous multi-user collaborative shared VE tools to the immersive scientific visualization environment.

(2) Implementation of sample software sufficient to demonstrate the underlying soundness of the design framework.

(3) Demonstration of device-independence within a running application in both a full immersive environment and the desktop environment.

Though the ultimate goal of SBIRs is manufacture and commercialization the Phase 1 would require only a simple implementation (with source and executable codes).

9.06 Intelligent Control

9.06.1-2 Applying AI Tools and Techniques to the Real-Time Control of Intelligent Systems

There is a clear gap between traditional Artificial Intelligence (AI) systems that typically work solely on symbolic representations, and real-time control systems that rely on processed sensor data, usually in the form of geometric knowledge or metrical maps. However, with constant advancements in object recognition technologies and the ever increasing computer processing speeds, these control systems seem primed to be able to leverage existing AI tools and techniques to allow for more suitable and robust control of intelligent systems.

This solicitation is seeking proposals for AI tools, representations and/or techniques that could enhance the ability of real-time control systems to understand the environment and propose suitable actions. Prime areas for applying AI techniques are in the areas of situation awareness and dynamic planning (also referred to in some domains as tactical behaviors); in particular, providing the ability for an intelligent system to be able to identify and understand a situation it encounters, be able to reason over the situation to deduce additional pertinent information, be able to understand the actions that are available to it when confronted with that situation, and be able to decide among those actions to determine which best accomplishes a given goal. The need for this type of deductive logic is ubiquitous, and can be applied to many manufacturing and non-manufacturing areas, ranging from manufacturing cell control to autonomous vehicle navigation.

The awardee(s) will work closely with NIST staff members who are developing control systems based upon the 4D/RCS reference model architecture. The primary Phase 1 deliverables are a detailed design document and a proof-of-concept implementation showing the overarching architecture and detailed interactions between the proposed AI tool suite and the 4D/RCS control architecture. The proof-of-concept implementation should show how the proposed solution could be applied to a sample scenario in the manufacturing or autonomous vehicle domain. The primary Phase 2 deliverable, if awarded, is a prototype implementation of the entire system. This will serve as the baseline for the hardened tool set that will be made available for commercialization in Phase 3. If successful, the proposed tool set should have a strong potential customer base made up of researchers and developers wishing to embed more intelligence in their control systems, independent of their domain of interest.

References:

Albus J., and Meystel A., Engineering of Mind: An Introduction to the Science of Intelligent Systems, New York: John Wiley and Sons, 2001.

Evans, J., Messina, E., Albus, J., and Schlenoff, C., "Knowledge Engineering for Real Time Control," Proceedings of the International Workshop on Intelligent Knowledge Management Techniques (I-KOMAT 2002), Crema, Italy, 2002.

Uschold, M., Provine, R., Smith, S., Schlenoff, C., and Balakirsky, S., "Ontologies for World Modeling in Autonomous Systems," Submitted to the IJCAI'03 Conference: Workshop on Ontologies and Distributed Systems, 2003.

9.07 Manufacturing System Integration

9.07.1-2 Ontological Engineering Applied to Manufacturing System Integration Research

The Manufacturing Engineering Laboratory is soliciting proposals for the application of the principles behind ontological engineering towards the area of manufacturing systems integration and/or research. The result of this effort will be mechanisms, infrastructures, and/or methodology tools with an ontological underpinning that will facilitate the interoperability of manufacturing systems. Within the former area, these principles may be applied to information that is to be shared among manufacturing applications, including, but not limited to, process, resource, product, and design information. Special emphasis will be given to proposals that are applicable to multiple types of information.

In the context of this proposal, an ontology is an explicit treatment of some topic as a written report. Included in this report would be the ontological formal and declarative representation, which includes the vocabulary (or names) for the terms in that subject area and the logical statements that describe what the terms mean and how they can or cannot be related to each other. The report should reflect that ontologies provide a formal means for representing and communicating knowledge about some topic and a set of relationships that hold among the terms. Without these formal and concise definitions of attributes, relations, and concepts, usually built upon some type of foundational theory, integration of manufacturing applications runs the risk of misinterpretation of those concepts, leading to problems with interoperability and exchange.

NIST is willing to collaborate with the awardee(s).

9.07.2-2 Integrated Process Modeling

The vision of "first part correct" demands a different approach in many areas of manufacturing engineering. New concepts such as predictive process engineering and science-based manufacturing will require a physics-based understanding of material removal manufacturing processes, advanced process metrology methods, valid analytical models to predict process performance and optimize manufacturing decisions, and rigorously-defined representations for manufacturing process information. There will be a shift from classical feedback quality assurance and optimization to model-based feed-forward process design and quality control. Product and process designers will have knowledge of and access to process specifications, manufacturing knowledge, and predictive process models to generate product and process designs seamlessly to produce the correct part the first and every time. To meet these needs, a number of areas are being addressed in parallel.

The existence and usability of process characterization models represent a central component of the first part correct vision. The process models describe the manufacturing process capabilities based upon proven theories and techniques, including analytically derived relationships, dynamic equations, empirical correlations, and statistical inferencing. Key issues include (1) validation of the process models to ensure accurate results and to instill confidence to potential users and (2) usability of the process models to integrate and incorporate these models into engineering applications throughout the product lifecycle where decisions are made. To improve manufacturing productivity and reduce lifecycle costs, appropriate mechanisms must be developed to enable use of manufacturing knowledge throughout the entire product lifecycle.

NIST is requesting proposals to address tools, methods, data representations, and/or prototype implementations for validation of physics-based process models for milling and turning operations and integration of these models to improve engineering applications. The focus of this effort will be on use of the process model as a tool, rather than viewing the model as an end-goal in itself. As part of this work, software modules will be created and supplied to NIST that will integrate with and extend the capability of the existing Process Integration Framework effort. This NIST activity is developing an integration framework and prototype agent-based software system to improve product design, manufacturing process planning, and machining execution through use of process knowledge from predictive models. Further, use of the current draft standard Process Specification Language (PSL) is strongly recommended. The awardee will work closely with NIST staff who are developing relevant process models, PSL, and prototype implementations of the Process Integration Framework. During Phase 1 the awardee will be expected to deliver software source code and initial demonstration capability in one or more of the areas indicated and an extended implementation for Phase 2.

9.07.3-4 High-Resolution, Two-Dimensional Electronic Neutron Detectors for Imaging

NIST uses two-dimensional neutron imaging detectors for several important applications: neutron radiography, neutron tomography, neutron phase contrast imaging, small angle neutron scattering, neutron reflectometry, and neutron beam diagnostics. In most of these applications, improved resolution is very badly needed. However, there is a lack of commercial development of high resolution two dimensional neutron detectors in the US and at present, most of the efforts to develop such detectors are being carried out in Europe and Japan.

Our most demanding current use of these two-dimensional imaging devices involves high-resolution neutron imaging of hydrogen fuel cells, which are being developed for new-generation automobile power sources, residential use and portable electronic devices. Higher resolution neutron detectors are critical in developing diagnostic tools that are needed for rapid development and commercialization of fuel cells.

The objectives of proposals on the subtopic should be to develop two dimensional electronic detectors and fabrication techniques that provide improved resolution (better than 25 micro-meter), improved efficiency (50% or higher), larger active area (larger than 10 cm2), and reduced cost.

Proposals submitted under this subtopic may address access to NIST facilities and staff. NIST is willing to collaborate with awardee(s).

9.07.4-5 Multiaxial Extensometry for Sheet Metal Forming Control

NIST has a need for a new, biaxial extensometer that can be used to control forming processes. The device needs to measure multiaxial strains dynamically and in situ, and reduce the data with sufficient accuracy and speed so as to be able to input the measurements into a feedback system that will be designed to control the hydraulic system on a sheet metal forming system. The goal of this project is to produce a total metrological and control system that will allow any arbitrary multiaxial strain path to be input and applied to a sheet metal sample from zero strain to failure using existing NIST forming machinery.

The awardee(s) will deliver the developed basic device to NIST at the conclusion of Phase 1. If awarded, a phase 2 will implement the full intended control features.

NIST personnel will work collaboratively with the awardee(s) to optimize the design of the devise, but will not be involved in fabrication or design of data acquisition and reduction system.

The awardee(s) will need access to NIST facilities for this task.

9.07.5-2 Manufacturing Data Exchange Standards Interoperability Testing Tools

Manufacturers attempting to solve Computer Aided Design (CAD) and Computer Aided Engineering (CAE) interoperability problems through use of the international Standard for the Exchange of Product model data standards (STEP) require objective technical means to assure the compatibility of commercial software applications. Similarly, commercial software vendors, seeking to satisfy their customers, seek the capability to test their STEP implementations during the development cycle. Software deployment pilot programs are an effective means to test implementations to information exchange standards. However, test pilots cannot be effective unless tools are available to isolate sources of exchange errors. Once isolated, translator errors and incompatible interpretations of a specification may be rectified in order to improve the capability of the participating implementations.

NIST is soliciting proposals to provide the technical infrastructure software tools necessary to support STEP implementation interoperability testing trials and to realize STEP conformance testing services. The focus of this effort is in the following areas:

Computer Aided Design to Computer Aided Manufacturing – Numerical Control (NC) for Machine Tools.

Computer Aided Design to Computer Aided Engineering – Finite Element Analysis (FEA).

The result of this effort shall be written reference test case data and test metrics for exchange testing as well as software tools capable of validating that neutral exchange data meets the requirements of the specified standard.

NIST is willing to collaborate with awardee(s).

9.08 Microelectronics Manufacturing

9.08.1-5 New Process and Apparatus Development for Manufacturing Novel Semiconductor Nano-whiskers

Semiconductor nano-whiskers (NWs) offer new revolutionary applications for optoelectronic (lasers, detectors), microelectronic (chemical and biological sensors) and thermoelectric (micro/nano-coolers, power generators) devices [1-4]. One of the key technical obstacles for realizing commercial success in manufacturing nano-devices is the lack of ability to fabricate NW structures with controlled size (i.e., desired diameter and length) and defects. Often, the nano-fabrication methods for the semiconductor materials of interest are immature or not yet demonstrated.

NIST is developing a methodology for fabrication and characterization of semiconductor NWs and related prototype photonic, electronic, and thermoelectric test structures, and is establishing best practices for new nanoscale metrology methods for the determination of optical, electronic, and transport phenomena in NWs. We have identified three material systems, namely ZnO, GaN and Bi_2Te_3 compound semiconductors, which will enable us to broadly address the metrology challenges and the key technology applications envisioned.

We are requesting proposals to develop a manufacturing process(es) and equipment for fabricating NWs of aforementioned materials with controlled properties. The manufacturing processes/systems should utilize vapor transport and/or chemical-vapor-deposition (CVD) approach and are required to meet the following specifications: 1) should be capable of fabricating ZnO and GaN NWs in the same process run without removing or exposing samples to the atmosphere (this is not a requirement for the Bi_2Te_3 NW fabrication, which is assumed to be a stand-alone process in the same system); 2) should have programmable multi-zone temperature gradient on a length scale up to 1000 mm; 3) should be equipped with multiple points accurate temperature monitoring across the reactor zone with the $\pm 5^oC$ accuracy and $\pm 1^oC$ precision; 4) should have multi-gas, flow-rate-controllable capability allowing fabrication of the NW samples in various gas mixtures, 5) should be able to operate at controllable pressure (from 1 atm down to least 0.01 atm); 6) should accommodate up to 25x25 mm square substrates (or 1" round wafers) on which the NWs will be grown.

Phase 1 results are expected to demonstrate that the newly developed manufacturing system fabricates ZnO, GaN and Bi_2Te_3 NW samples with reproducible properties. The test NW samples are expected to be delivered to NIST for testing and evaluation. At the end of Phase 1 the awardee will manufacture and deliver to NIST the laboratory-scale prototype system. At the end of Phase 2 the awardee will manufacture and deliver to NIST the scale-up manufacturing system with in-situ process monitoring capabilities (to be specified after successful completion of Phase 1).

NIST intends to communicate with the awardee throughout the project providing technical advice on the manufacturing process development and ensuring the specifications are met.

References:

1. L. Samuelson, M.T. Björk, K. Deppert, M. Larsson, B. J. Ohlsson, N. Panev, A.I. Persson, N. Sköld, C. Thelander, and L.R. Wallenberg, “Semiconductor nanowires for novel one-dimensional devices”, Physica E, 21 (2-4), p.560 (2004).

2. C.M. Lieber, “Nanoscale science and technology: Building a big future from small things”, MRS Bulletin, 28 (7), p. 486 (2003).

3. Y. Cui, Q.W. Hongkun Park, and C.M. Lieber, “Nanowire Nanosensors for Highly Sensitive and Selective Detection of Biological and Chemical Species”, Science, 293, p. 1289 (2001).

4. W. Wang, F.L., Jia, Q.H. Huang, M.L. Zhang, H.T. Guo, and Y.T. Shen, “Electrochemical assembled p-type Bi2Te3 thermoelectric materials with nanowire array structure, J. of inorganic materials, 19 (3), p. 517 (2004).

9.08.2-1 Development, Manufacture, and Commercialization of 110 GHz Traceable Electrical Phase Standards

We are soliciting proposals to develop, manufacture, and commercialize inexpensive waveform generators that can be used as electrical phase standards traceable to NIST’s Electro-optic Sampling (EOS) System. The waveforms could be generated by pulse or comb generators. The waveform generator must be accurately characterized and mismatch corrected. It is difficult to perform more than a few calibrations a year on the NIST EOS system. Thus the calibrations must be achieved without requiring a large number of measurements on NIST’s EOS system. The awardee(s) is expected to achieve this by developing a suitable calibration transfer system that only need be calibrated occasionally by transfer of an artifact or measurement head to NIST for calibration. The waveform generators themselves should be capable of calibrating a wide variety of both temporal and frequency-domain measurement systems, including oscilloscopes, large-signal network analyzers, and bit error rate testers. The devices must be stable and generate enough energy to allow calibration to 50 GHz in 2.4 mm connectors, 65 GHz in 1.85 mm connectors, and 110 GHz in 1.0 mm connectors.

The awardee(s) would need to deliver system prototype for evaluation and use at NIST during Phase 1 and a fully developed version in Phase 2. The awardee(s) could retain ownership of the Phase 1 prototype, but we wish to keep the Phase 2 device at NIST to enable testing and round robins.

In order to achieve traceability to the NIST EOS system, NIST would collaborate with the awardee(s).

9.08.3-1 STEP AP210-based Stackup Design & Warpage Analysis Tool for Printed Circuit Board Manufacturing

Printed circuit boards (PCBs) are multi-material structures that are one of the backbones of the electronics industry. As their performance requirements and complexities increase, the need also increases to better manage z-directional factors including warpage, impedance control, and plated through-hole reliability.

Reducing warpage in PCBs and other electronic packages is a particular challenge today for reasons including:

a) Warpage is a difficult phenomenon that depends on factors such as complex material behavior, fabrication processing, assembly manufacturing, and other environmental conditions (e.g., humidity).

b) The information needed to enable effective warpage simulation is not well defined and managed. The design and specification of PCB stackup (i.e., details about the z-direction PCB cross-section) is another key aspect that influences warpage. However, such design and fabrication knowledge is complicated, it often spans multiple organizations (e.g., the PCB design organization and the PCB fabricator organization), and it has no well-established exchange protocol.

c) The PCB design model has many circuit layout features that must be considered and yet idealized to create reasonable warpage analysis models. A rich design model is needed to feed this process, and a design-analysis interoperability architecture is needed to support various levels of abstraction and a diversity of CAD tools, material libraries, solution methods, and CAE tools.

Recent advances provide promising technologies and directions to help solve these problems. In particular the AP210 standard (ISO 10303-210) enables rich product models for electronics, while engineering framework concepts are emerging that help fill information gaps and enhance standards-based model interoperability.

NIST is soliciting proposals to provide innovative software tools that explore these technologies and their ability to solve the PCB warpage problem. This effort will focus on the highly automated analysis modules that guide PCB design and reduce warpage. Collaboration with other organizations is anticipated in the areas of fabricator needs and test usage, material characterization, and metrology (for results verification).

The result of this effort shall be software tools and techniques that embody the above capabilities. Awardee(s) will provide a software prototype and documentation in phase 1. It is expected that NIST will collaborate extensively with awardee(s).

References:

1. Papers about warpage issues and metrology. http://www.akrometrix.com/downloads.htm

2. Infrastructure for Integrated Electronic Design & Manufacturing.
http://www.eeel.nist.gov/811/manufacture.html

3. Systems Integration for Manufacturing Applications (SIMA) program. http://www.nist.gov/sima/

4. ISO 10303-210 standard for electronics. http://www.ap210.org/

5. TIGER project. http://eislab.gatech.edu/tiger/

6. Engineering Framework Interest Group (EFWIG). http://eislab.gatech.edu/efwig/

9.08.4-1 Product Model-Based Simulation for Manufacturing

One key to enhance the competitiveness of U. S. small and medium-sized enterprises (SMEs) is their ability to simulate the physical behavior of products and manufacturing processes. Through techniques such as finite element analysis, SMEs can greatly impact products by optimizing their performance, judging design alternatives, and improving manufacturing yields. However, industry often does not benefit from such simulations due to the lack of easy-to-use product-specific capabilities. This situation is exacerbated in SMEs where limited resources typically preclude having in-house analysis tools and staff. Yet SMEs need analysis capabilities, as they are often the ones with the precise product and process knowledge required to realize improvements.

NIST is soliciting proposals for innovative software and technology infrastructure that will overcome these challenges. The following capabilities are required:

a) A methodology for creating highly automated analysis modules that can be deployed as self-serve Internet-based engineering web services.

b) A design-analysis interoperability architecture that enables such analysis modules. This architecture shall support a diversity of CAD tools, design domains, physical behaviors, solution methods, and CAE tools. It shall also capture idealization knowledge and support various levels of abstraction.

c) A standards-based approach for engineering frameworks that fills fundamental gaps including content coverage, content semantics, and fine-grained associativity.

This effort shall apply these general techniques to create capabilities that will aid printed circuit board (PCB) fabricators and designers in the electronics domain. Exemplar analysis modules shall be developed for behaviors that are not well supported today like PCB warpage. SMEs shall be able to feed these analysis modules with design information in the form of rich AP210 product models (the ISO 10303 standard for electronics).

The result of this effort will be methods, software tools, and web services with the above capabilities. Awardee(s) will provide prototype versions of these items in phase 1. It is expected that NIST will collaborate extensively with awardee(s).

References:

1. Systems Integration for Manufacturing Applications (SIMA) program. http://www.nist.gov/sima/

2. Infrastructure for Integrated Electronic Design & Manufacturing.
http://www.eeel.nist.gov/811/manufacture.html

3. TIDE (Technology Insertion Demonstration Experiment) project.
http://www.mel.nist.gov/msid/pe.htm

4. ISO 10303-210 standard for electronics. http://www.ap210.org/

5. Engineering Framework Interest Group (EFWIG). http://eislab.gatech.edu/efwig/

6. TIGER project. http://eislab.gatech.edu/tiger/

9.08.5-1 Development, Manufacture, and Commercialization of Traceable 400 GHz On-wafer Sources

We are soliciting proposals to develop, manufacture, and commercialize optically-driven on-wafer microprobe-based electrical pulse generators with a 400 GHz bandwidth that can be used as electrical pulse standards traceable to NIST's Electro-optic Sampling (EOS) System. The intent is to develop standards that can be made traceable to the NIST EOS system. While the awardee(s) is not expected to actually establish this traceability, they are expected to understand the difficulties involved and develop probes capable of being tested and made traceable to the EOS system by NIST workers. The probes are to have an optical fiber input upon which fast optical excitation pulses enter the probe. The probes are to have electrical probe tips to launch internally-generated electrical waveforms onto integrated circuits. The waveforms could be generated internally by company-developed photodetectors, company-developed photoconductive switches, or by NIST developed photoconductive switches. The pulse generators must be able to couple energy directly onto coplanar waveguides and microstrips fabricated on different wafers by way of these electrical probe tips. When working in coplanar waveguide, the pulse generators should be designed to couple the pulse energy into the coplanar waveguide mode of on-wafer coplanar waveguides with minimal excitation of the coplanar slot or microstrip modes. The electrical pulse generators must be able to generate electrical waveforms on-wafer with pulse heights of at least 0.25 V and 3 dB bandwidth of 150 GHz with a continuous suck-out-free spectrum of energy above 20 dB to 400 GHz in NIST coplanar waveguides fabricated on $LiTaO_3$. NIST will verify this performance on their EOS system. The electrical match of the probes should be nominally 50 ohms. Probe architectures that could support high-speed samplers for simultaneously performing time-domain reflectrometry as pulses are generated would be preferable to architectures that are only able to produce fast electrical pulses.

The awardee(s) would need to deliver system prototype for evaluation and use at NIST during Phase 1 and a fully developed version in Phase 2. The awardee(s) could retain ownership of the Phase 1 prototype, but we wish to keep the Phase 2 device at NIST to enable testing and round robins. We also expect the awardee(s) to make the probes commercially available both to NIST and to other companies after the work is completed.

In order to achieve traceability to the NIST EOS system, NIST would collaborate with the awardee(s). NIST also envisages that the awardee(s) may wish to take advantage of high-speed photoconductive switch technology being developed at NIST for this purpose.

9.09 Microfabrication and Micromachining

9.09.1-2 Autocollimator Instrument for High Precision Micro Mechanism Devices

During the last few years we have been experimenting with various high precision micro/nano positioning devices. These devices generate very accurate straight line motions with minute cross talk and angular deviation errors. Our Dual Parallel Cantilever Micro/Nano Positioner (http://www.isd.mel.nist.gov/meso_micro/) has angular deviation errors of the order of 0.1 arc-seconds, about three orthogonal axes X-Y-Z, for a range of motion of 130 by 130 micrometers, along the X-Y plane.

One promising new technology is that of Micro Electro Mechanical Systems (MEMS), which have components with features of dimensions smaller than 1 mm. MEMS devices have the potential to revolutionize the market of sensors, metrology instruments and micro/nano fabrication technology. We have started building MEMS scale versions of high precision micro positioners and we would like to measure their angular deviation errors, about three orthogonal axes X-Y-Z, for a range of motion of 30 by 30 micrometers, along the X-Y plane. Unfortunately the existing instruments, usually referred as autocollimators, cannot be used in the case of small devices like the one we are fabricating.

We solicit proposals for the development of new instruments capable to measure the angular deviation of moving high precision MEMS micro mechanism devices. The ideal instrument for such application would have the following characteristics:

- Accuracy Error: Less than 0.05 arc-seconds.

- Resolution: At least 0.01 arc-seconds.

- Target Size: 0.5 mm or smaller.

- Simultaneous two orthogonal axes measurement.

- Target Range of Motion: 50 micro meters or greater.

If the awardee(s) desires, the NIST staff sponsoring this subtopic will be willing to collaborate with the awardee in data collection and experiments in NIST labs. The NIST staff will make available experimental prototypes of micro devices for the testing of the autocollimator instrument.

Phase 1 deliverables: A technology survey and evaluation report for autocollimator technology, which can meet the performance characteristics listed above

Phase 2 deliverables: If a phase 2 award is made, an engineering prototype and demonstration of the instrument, which meets the performance characteristics listed above, will be expected.

9.09.2-2 Very High Accuracy Probe for Micrometer Scale Structures

The use of structures with dimensions less than 200 micrometers is a very important trend in evolving manufacturing capabilities in the United States. The importance over the last decade of optical fibers (125 µm diameter) and fuel injector nozzles (less than 100 µm) have been joined by a wide range of new industrial needs over a broad spectrum of manufacturing. New products, such as drug delivery systems (5 µm to 20 µm holes) and microfluid control systems (chemical and biological analysis instruments) brought new demands for dimensional calibrations from industry sectors that have never needed NIST measurement services before. To meet these new needs the sensor capabilities of our instruments must be extended to both smaller dimensions and smaller forces.

NIST has the most accurate three-dimensional measuring machine available, and it has been shown to have the positioning accuracy and control for these applications. There is, however, no available three-dimensional probing system good enough to use this positioning accuracy. The current probe system is nearly good enough, but the force and reproducibility is short of what is needed and the manufacturer is no longer in business. To meet the needs of our customers we need a contact probe with a variable force (1 gram-force to 50 gram-force) and a repeatability of 5 nanometers or better. The goal of the program is a commercial grade probe (e-stop and over-travel provisions, suitable mounting hardware, etc.) which will allow us to fully use the demonstrated accuracy of our measuring machine.

Phase 1 of this research should demonstrate the feasibility of developing and fabricating this three-directional probe and for interfacing it to our existing measuring machine. Phase 2 includes manufacture and testing of the prototype probe on the NIST M48 measuring machine and will be done with the cooperation of the NIST staff. Demonstration of the feasibility of the three-directional probe and its interface to and operation on the existing NIST M48 measuring machine is to be in collaboration with NIST staff at NIST.

At the completion of Phase 2, the awardee(s) is to deliver to NIST, for its retention and ownership, a prototype variable-force (1 gram-force to 50 gram-force), high- repeatability (5 nanometers or better) three-directional contact CMM probe of a commercial grade (i.e. e-stop, over-travel provisions, suitable mounting hardware, etc) for use in measurement of features tens of micrometers in size.

9.09.3-2 Development of Meso Scale Machine Tools

The micro-meso fabrication market is expanding to meet the demand for increased functionality, reliability, and performance for smaller components that are frequently used in optoelectronics, medical equipment, sensors, communications, aerospace, and automotive industries. In manufacturing of micro-meso products, machining has a significant advantage in being able to generate three-dimensional complex shapes out of a wide range of materials. In addition to being very agile, machining is also able to produce high accuracy and surface finish compared to other manufacturing methods. Therefore, meso machine tools are clearly one of the most important enablers in micro-meso manufacturing. Improvements in machine tool technologies are tightly coupled with the development of proper metrology tools and methods, as evidenced by the improvements in CMMs and conventional machine tools.

NIST is currently exploring the metrology challenges and opportunities for such machines. The metrology challenges include 1) the required dramatic improvements in machining accuracy, 2) the lack of space for metrology components, 3) the difficult application of process-intermittent inspection due to the small feature sizes, and 4) the difficulties in achieving repeatable part fixturing, requiring multiple operations in one setup. The small work volume required by the machining applications, however, also presents unique opportunities for the application of superior metrology concepts that radically depart from classical machine tool metrology.

In order to facilitate these efforts, NIST is seeking proposals to design and develop innovative multi-axis meso-scale machine tools that would serve as test platforms for developing and evaluating new metrology tools and concepts as well as research in micro-meso scale machining. The machine that is of interest would have a work volume of 50 mm cubed or less. The proposed work should involve prototype development. The prototype system would be a deliverable to NIST for the Phase 1 effort. The prototype system would be retained by NIST, with the understanding that the contractor would be provided access to the equipment if successful in receiving a Phase 2 award. NIST is willing to collaborate with the awardee(s).

Proposals that emphasize low cost and innovative structures, drive/actuator, metrology, and sensing technologies while addressing the challenges mentioned above are strongly encouraged.

9.09.4-5 Mixing/Dispensing System for Combinatorial Polymer Formulations Libraries

Scientists at NIST and in industry are actively developing combinatorial and high-throughput approaches to accelerate the development of complex polymer formulations for a variety of technologies, including advanced coatings, packaging materials, electronics encapsulants, tissue scaffolds and personal care products. These approaches require means to fabricate multivariate specimen arrays, i.e., discrete and continuous composition gradients, that systematically vary three or more viscous polymer components, some of which may contain particulate fillers. Moreover, many emerging manufacturing strategies, aimed a producing complex meso-scale polymer structures and devices, increasingly require the ability to dynamically formulate and deposit viscous polymer mixtures at the point of application.

To meet these challenges, NIST is soliciting proposals for the development and delivery of a mixing/dispensing system to:

A. Dynamically mix, under computer control and in any ratio, at least three viscous polymer liquids, primarily viscous polymer solutions in common organic solvents. The system should also be capable of handling components that contain suspended micrometer scale solid particles.

B. Deposit, under computer control, point, line and planar specimen arrays of these formulations that systematically vary in their composition. The system should be capable of dispensing both discrete specimens and gradient (continuously changing) specimens with microliter resolution.

Phase 1 will focus on the delivery of a prototype blending pump system (mixing head) with the following specifications:

1) Computer controlled mixing (blending) and dispensing of viscous polymer liquid formulations with at least three components in any ratio.

2) Mix and dispense liquids with a viscosity range of 100,000 to 700,000 Centipoise (CPS).

3) One of the three mixing channels should be able to handle liquids loaded with suspended particles with micrometer range diameters.

4) The blended polymer fluids shall exit the mixing device through a common orifice to produce a single point or track of liquid material with microliter resolution.

5) The mixing head will allow dynamic variation of the blending ratio during the dispensing process, such as required to produce continuous composition gradients.

Phase 2 will combine the Phase 1 deposition head with a computer driven motion control station towards the delivery of a system capable of dispensing point, line and planar gradient specimen arrays on planar substrates.

Additional specifications for the Phase 2 system:

1) 3 axes of motion (X/Y/Z), with a range of at least 150 mm in each direction, a repeatability of +/-5 micrometers in each direction and a controlled velocities up to 150 mm/sec in each direction;

2) The ability to import files that specify specimen array layouts (e.g. CAD files dxf/dwg);

3) A menu and icon based operator interface; and

4) A sample platen capable of securing planar specimen substrates at least 150 mm in diameter and 2 mm thick.

In addition, it is desirable to have a system that includes a video camera for monitoring the deposition process.

NIST is willing to collaborate with the awardee, by providing model polymer liquid specimens, viscosity standards and performance feedback on the Phase 1 mixing head, including chemical analysis useful for validating gradient specimen arrays produced by the device.

NIST will retain prototype devices produced in Phase 1, and Phase 2 if awarded, after the termination of the SBIR contract(s). If a phase 2 is awarded, NIST may return the phase 1 prototype to the awardee after delivery of the phase 2 system.

9.10 Microwave Technology

9.10.1-1 Sampling Broadband Radio-Frequency Signals for Precision Nonlinear Network Analysis

In order to fully characterize the response of RF and microwave mixer circuits, the microwave community requires a new sampling technology. This new technology must be capable of sampling periodic broadband RF signals that contain numerous frequency components that are not harmonically related. It must also provide a method of correcting the sampled signal for the imperfections of the sampler itself, as it is often hard to identify the response of an RF device under test from that of the sampler response when operated at microwave frequencies. The development of the sampling technology and calibration methods will provide new capabilities beyond what is now available, or known to be available. It will enable nonlinear circuit characterization and the exploration of microelectronic device behavior that is not possible at this time, and will provide significant technological advantages to the nonlinear RF circuit measurement work NIST and to the radio-frequency technology community at large.

Sampler Goals

We envision an instrument or instrument subsection with 6 inputs. Each input will be sampled in order to recover all the significant spectral components of each broadband input. The output of the instrument block will either be calibrated, time-sampled data, or a down-converted representation of the input. If the latter, we require a calibration procedure to remove the complex transfer function of each sampler from each of the 6 signals. The calibration procedure should be provided in software. All solutions should provide ready access to the most basic signal or data for NIST calibrations and statistical evaluations.

The input bandwidths would ideally cover a span from dc to 50 GHz. As this is known to be quite difficult, research in a sub-range would provide valuable information. If a down-converter is developed, it’s output (IF) bandwidth should be in the range of 10^{-40} MHz. The sampler should also be sensitive to components at small signal amplitudes (-60 dBm, or less) with as broad a dynamic range as possible.

While electrical sampling is a likely technology to pursue, optoelectronic sampling is a possible option. However, the inputs will always be electrical, delivered on coaxial cable using standard connectors. The output can be either data or electrical signals for subsequent time-sample digitization.

Deliverables expected include a waveform sampler with at least 4 inputs, and preferably 6 and the source code for instrument control, frequency component identification, and sampler correction. NIST anticipates to collaborate with the possible awardee(s).

9.11 Nanofabrication

9.11.1-1 Improved Fabrication of Silicon Single-Electron Transistors

NIST has had a long-standing interest in single-electron tunneling (SET) devices. There are two basic functions of this class of devices that are important for NIST: 1) pumps and turnstiles which can move electrons one by one offer the potential for a fundamental standard of current or charge; 2) SET transistors have the best charge sensitivity of any solid-state device, and therefore offer the potential for ultrasensitive charge electrometry.

Up until now, NIST has had the capability to fabricate metal-based SET transistors; the fabrication involves only a few process steps. Recently, for several different reasons, we have started a program in investigating Si-based SET devices. Among the reasons for this interest are: 1) The apparent lack of charge offset drift, which is an endemic problem in the metal-based devices. 2) The ability to reach higher operating frequency and higher temperature with the Si-based devices. 3) The fact that the future of the microelectronics industry, if it uses any single-electron device, will almost certainly be Si-based rather than metal-based.

To flesh out the last point, we refer to the most recent ITRS technology roadmap, in which single-electron devices are referenced several times as possible candidates for beyond CMOS.[1]

Improving competitive capability:

Although single-electron devices are considered one candidate for beyond CMOS, there do not appear to be any companies in the United States that are pursuing this possibility. In particular, a niche exists at present for a small company to develop a fabrication process with manufacturing robustness. The world leaders in fabricating Si SET devices are at present a company in Japan[2], and an academic research group in Korea.[3] To date, neither of these groups has demonstrated the ability to make a large number of uniform single-electron devices with high yield. A typical result is that the yield is between 10 and 50 percent, with a factor of two variation in the device parameters.[4]

Manufacturing-related R&D:

This subtopic represents a manufacturing-related R&D subtopic, in particular "development of new manufacturing processes, including new materials, coatings, methods, and practices associated with these processes". The subtopic would require the awardee(s) to develop a new method for integrating nano fabrication processing in such a way as to develop a reliable, robust set of devices.

If the awardee(s) is partially or fully successful in this subtopic, NIST researchers would be very interested in getting some of their devices, so that we could measure them in our measurement system. The information obtained from these measurements would be essential to the small company in further developing the technology.

Goals:

The goal of both phases of the SBIR would be to fabricate Si-based SET transistors with a high yield and a small range of device parameters within a die and between dies. The specific device that we suggest fabricating as a test would be a device with tunable barriers: Si channel on a SOI wafer, with two lower gates to define electrostatically the tunnel barriers, and one upper gate to invert the channel and to modulate the potential of the SET island.

It is expected that NIST will collaborate extensively with awardee(s).

References:

[1] http://public.itrs.net. See the chapter entitled "Emerging Research Devices".

[2] “Silicon single-electron devices”, J. Phys: Condens. Matter 14, R995 – R1033 (2002).

[3] “Silicon Single-Electron Transistors with Sidewall Depletion Gates and their application to Dynamic Single-Electron Transistor Logic”, IEEE Trans. Elec. Dev. 49, 627 (2002).

[4] “Microscopic Observations of Single-Electron Island in Si Single-Electron Transistors”, Jpn. J. Appl. Phys. 42, 2438 – 43 (2003).

9.11.2-3 Instrumentation for Integrated Nanofabrication and Optical/electronic Characterization

A key challenge in the development of nanoscale devices is the ability to fabricate and interrogate those structures in the same instrument. Scanned probe based fabrication offers several advantages in terms of prototyping nanoscale device architectures, but carrying out further measurements such as optical and electrical tests on the fabricated structures on the same platform is currently limited to only a few custom designed systems. NIST seeks the design and construction (delivery of prototypes) of a practical scanned probe based nanofabrication platform, which will allow for the directed design and fabrication of surface architectures using molecules, nanoparticles, metals, inorganic and biological components. The system should be capable of simultaneous fabrication of two-dimensional architectures with a minimum of 5 different components with < 5 nm spatial resolution placement capability over areas of 100 mm^2. An integrated means for concomitant optical and electrical characterization must also be provided to allow for the direct measurement of the resulting physical properties of the fabricated structures without the need for transferring the sample to another system. Control of local environment and sample temperature is also required. The delivery and testing of prototypes in Phase 2 at NIST Advanced Measurements Laboratories can be possible in cooperation with NIST personnel. The successful development of such an instrument would significantly enhance the ability for manufacturing nanoscale device systems.

9.12 Optics and Optical Technology

9.12.1-4 Femtosecond Optical Frequency Synthesizer Based on Yb-doped Fiber Laser for Precision Measurements

The recent merge of precision optical frequency metrology and ultrafast laser technology has made a profound impact to a number of scientific disciplines, including fundamental physical tests, precision spectroscopy in chemistry, biology, and material science, metrological support in space science, and coherent quantum control. For the area of frequency metrology, we expect a significant increase in the stability and accuracy of the next generation optical frequency standards. Phase coherent connection between the optical and microwave spectral regions has now been established with direct optical frequency synthesis, with a qualitatively new regime being developed owing to the introduction of precise femtosecond laser based optical frequency comb technology. Perspectives of femtosecond synthesizers for a wide range of scientific applications have been explored and confirmed by the development of similar systems in leading scientific centers. However, almost all investigations up to now have oriented on the use of the well explored and commercialized Ti:Sapphire-based femtosecond laser systems. While volatile and reliable, Ti:Sapphire lasers need expensive and large pump lasers due to Ti:Sapphire's relatively low absorption efficiency and short life-time of the upper level in the active medium (3.2 microseconds). Development of an alternative system based on femtosecond diode-pumped ytterbium-doped fiber laser is needed. The system will be compact, highly efficient, as well as low cost. The relatively low thermal load and compactness of the laser system help to create stable optical resonators and to obtain highly reliable laser operating parameters. In addition, one needs to investigate spectral broadening of the Yb-doped fiber laser for possible establishment of a self-referenced Yb femtosecond comb. We expect that the Yb laser will be stabilized via narrow iodine transitions in the 514 nm wavelength region. This will stabilize the entire comb of the femtosecond Yb fiber laser and effectively establish a high quality optical frequency synthesizer.

We expect development in the following areas. Phase 1: Development and investigation of Yb-doped femtosecond lasers, with the following parameters: pulse duration, 100 - 200 fs; pulse repetition rate, 50 – 100 MHz lockable to an external clock with Allan variance less than 10^{-13} in one second; average power: 200 mW. Investigation of the stability and the noise floor associated with the femtosecond optical frequency comb produced by the Yb fiber lasers. Phase 2, if awarded: (1) Development of methods to control the offset frequency of the generated frequency comb. Investigation of spectrum broadening of Yb-doped fiber laser in highly nonlinear fibers including investigation of the envelope of the fiber generated spectrum; investigation of the noise characteristics of fiber bandwidth broadening; and investigation of the possibility of self-referencing optical frequency comb. (3) Work with NIST to incorporate the Yb laser into the Yb:YAG/I_2 frequency standard with short term (1 s) stability reaching ~10^{-14} and long term stability reaching ~10^{-15}. The Yb-doped fiber mode-locked laser is expected as a deliverable under phase 2.

9.13 Technologies to Enhance Fire Safety

9.13.1-6 Enhanced Fire Fighter Visibility

In response to structure fires, fire fighters typically enter structures to locate possible victims or conduct fire suppression. Structure fires often produce sufficient smoke to make it hard for fire fighters to maintain contact with each other. Research is required to determine if technology can allow fire fighters to maintain contact with other fire fighters in hot, steam and smoke filled rooms. This contact could be visual, such as a strobe light tuned to that part of the spectrum visible by thermal imagers or infrared cameras, or it could be acoustic, such as a system that emits a series of beeps when a fire fighter is aligned with another fire fighter. The frequency of the beeps or strobe flashes could increase as a fire fighter moves closer to a second fire fighter. The technology needs to provide sufficient information to the fire fighter so that the location of the second fire fighter can be quickly and correctly ascertained. This technology must be able to not alert a fire fighter that a second fire fighter is in the smoke filled room, but must be able to indicate whether the second fire fighter is to the front, rear, left or right side, of the first fire fighter. The system should also be able to handle multiple fire fighters so that if there are four fire fighters in a room, that each can understand that there are four separate fire fighters in the room. The technology used to maintain contact should not require the use of the hands of the fire fighter who is already carrying other equipment, such as hoses, axes, or extinguishers. This technology could be incorporated into existing fire fighter equipment, such as hoses, turn-out gear, extinguishers, helmets, Personal Alert Safety Systems (PASS), or self-contained breathing apparatus. The technology needs to be extremely light weight so to not burden the fire fighter with significantly more weight.

Proposals for incremental advances to existing reflective markers for protective gear or light sources are not solicited; however, proposals that address only a portion of this research are welcome. Phase 1 will demonstrate feasibility. In Phase 2, a functioning system for eight fire fighters will be delivered to NIST for further study.

9.13.2-6 Development of a High Throughput Foam Fabrication Device

Polyurethane foams are ubiquitous in our lives. They are used in building insulation, upholstered furniture, carpet padding, automotive and bedding products. Several factors have recently come together which collectively call for a concerted effort to improve the methods used to characterize the flammability of polymeric foam products. First, U.S. fire deaths attributed to the burning of objects utilizing polyurethane foam (cellular plastic) products remain a major fraction of the total fatalities recorded in home fires. Second, the impending ban of some of the more effective brominated flame retardants used in PU foam requires that new flame retardants be evaluated and optimized for foam products. Third, more stringent flammability requirements for automotive and residential furnishings are being considered by various agencies. However, the large number of chemical, processing and physical parameters that must be investigated to develop fire retardant foams demands that high throughput methods be developed. Specifically, such methods would help process improvement, additive screening, and property optimization in the development of improved foams. A bench scale (less than 1 kg/hr) foam fabrication method is desired. One done in a continuous manner (not batch) combined with the capability to continuously vary the chemistry, or any other parameter associated with the foam. Preparation of these “gradient” type foam samples are required. NIST will be willing to collaborate with the awardee to make any necessary modifications to existing equipment in order to provide the awardee with a test bed for developing the bench scale foam fabrication method.

Proposals for incremental advances to existing foam processing equipment are not of interest. However, new bench-scale methods that can prepare gradient samples of foam are desired. Phase 1 will demonstrate feasibility and deliver a prototype. If a phase 2 is awarded, a functioning system will be delivered to NIST.

Proposals submitted under this subtopic may address access to NIST facilities and staff.

9.13.3-6 Distributed Multi-Nodal Voice/Data Communication for Fire Fighters

Fire ground communication between fire fighting teams and between teams and incident command typically utilize hand held radios. Hand held radios may provide adequate communication when both parties are outside of buildings, but as a fire team moves inside a structure, the ability to communicate tends to degrade quickly. This is especially evident if the walls of the structure contain significant amounts of metal. Metal, such as aluminum siding or the aluminum facing on insulation, can be sufficient to prevent VHF, UHF, and ultra-wide band radio transmission. Research is required to determine if a series of distributed nodes could be used to relay both voice and data communications. Each node would have to be capable of receiving information from other nodes and then be able to relay that information out to other nodes until the information is communicated to the incident command that is typically located outside the structure. Each node would have to be able to “see” or maintain radio contact with other nearby nodes. This series of nodes need to be able to compensate if one or more nodes are suddenly removed from the network by thermal damage or structural collapse. The nodes will include voice communication between individual team members inside the structure, but can also communicate with incident command. The nodes will also link the fire teams and incident command for the transfer of data, such as “fire fighter down” or PASS device alarms. This technology could be incorporated into existing fire fighter equipment, such as hoses, turn-out gear, extinguishers, helmets, Personal Alert Safety Systems (PASS), or self-contained breathing apparatus. The nodes could also take the form of small deployable packages that are distributed by a fire fighter, by insertion into a room through a closed or open window, or by radio controlled insertion robotic devices. However, each node must be extremely lightweight, including power source, in order not to burden the fire fighter with significantly more weight.

Proposals for incremental advances to existing radio technology are not solicited; however, proposals that address only a portion of this research are welcome. Phase 1 will demonstrate feasibility. In Phase 2, a functioning group of nodes will be delivered to NIST for further study.

9.14 X-ray System Technologies

9.14.1-3 High Acceptance Area X-ray Detector for Analytical Electron Microscopy

A key limitation in the chemical characterization of nanoscale devices is the sensitivity of chemical detectors. Electron microscopes with x-ray detectors are a common approach to nanoscale chemical characterization, but the detectors are currently limited to less than 0.2 STR solid angle. The new generation of silicon drift x-ray detectors offer the promise of much larger solid acceptance angle for x-ray detectors in Analytical Electron Microscopes (AEM). NIST seeks the design and construction (delivery of prototypes) of a practical partial or complete doughnut shaped silicon drift or other equivalent energy dispersive x-ray detector system that can fit into the tight spatial limitations defined by the specimen chamber in the AEM. This may require multiple detector chips and multiplexing technology. The detector system shall have at least a 0.5 STR acceptance angle. The detector resolution shall be better than or equal to 150 eV during routine use on the AEM (count rates of under 100,000 per second per 0.1 STR.) The detector shall have sensitivity for x-rays in the energy range from 0.35 to 10 keV. The delivery to NIST and testing of prototypes in Phase 2 at NIST Advanced Measurements Laboratories is possible in cooperation with NIST personnel. The successful development of such an instrument would significantly enhance the ability for the characterization of nanoscale device systems and may be used in other systems such as Scanning Electron Microscopes to speed high spatial resolution analysis.

9.14.2-5 Imaging Variable Kinetic Energy (0.1 to 8 KeV) Electron Analyzer

NIST seeks the design and fabrication (delivery of prototypes) of a practical imaging variable kinetic energy (0.1 to 8 KeV) electron analyzer. The new analyzer will be used for synchrotron based depth selective X-ray photoemission spectroscopy (XPS) materials science applications. Our synchrotron beamline offers intense broad range tune-ability (0.7 to 8 KeV) of the X-ray excitation of a specific core level creating a variable electron kinetic energy and thus a new depth selective approach for XPS. By coupling this new depth selectivity and two-dimensional spatial detection the new imaging variable kinetic energy electron analyzer developed will empower a novel three-dimensional XPS non-destructive chemical bond sensitive probe of complex materials. It is anticipated that that this new method will offer strategic chemical and structural insights in nanotechnology applications such as IT devices, including organic electronics, MEMs lubrication, SAM templates, and catalysts.

Thus, we seek a new imaging variable kinetic energy electron analyzer to enable a novel synchrotron based three-dimensional imaging XPS method. The electron analyzer should be tunable over a broad range of kinetic energy preferably from 0.1 to 8 KeV through the development of novel high transmission electrostatic or magnetic electron optics. A novel parallel process-imaging detector will be coupled to the high throughput electron optics to provide a spatial resolution target of 100 nm or less. The delivery and testing of prototypes at NIST synchrotron facilities can be possible in cooperation with NIST personnel.

The successful development of a practical imaging variable kinetic energy (0.1 to 8 KeV) electron analyzer would be a very significant advance in the application of XPS at synchrotron research facilities in the United States. XPS is a valued analytical tool for companies and academia and is routinely applied for creating chemical maps of polymer surfaces, photoresists and other materials problems.

In a broader context the successful development of an imaging variable kinetic energy (0.1 to 8 KeV) electron analyzer would be a very significant advance in X-ray photoemission spectroscopy imaging. Currently, imaging XPS is often limited to one-dimensional analysis at relatively modest spatial resolution. The imaging variable kinetic energy (0.1 to 8 KeV) electron analyzer would provide an important practical improvement in XPS systems found in many analytical and researches laboratories throughout the United States.

Prototype delivery is expected for phase 1 and the fully implemented device will be deliverable under phase 2, if awarded.

Proposals submitted under this subtopic may address access to NIST facilities and staff.